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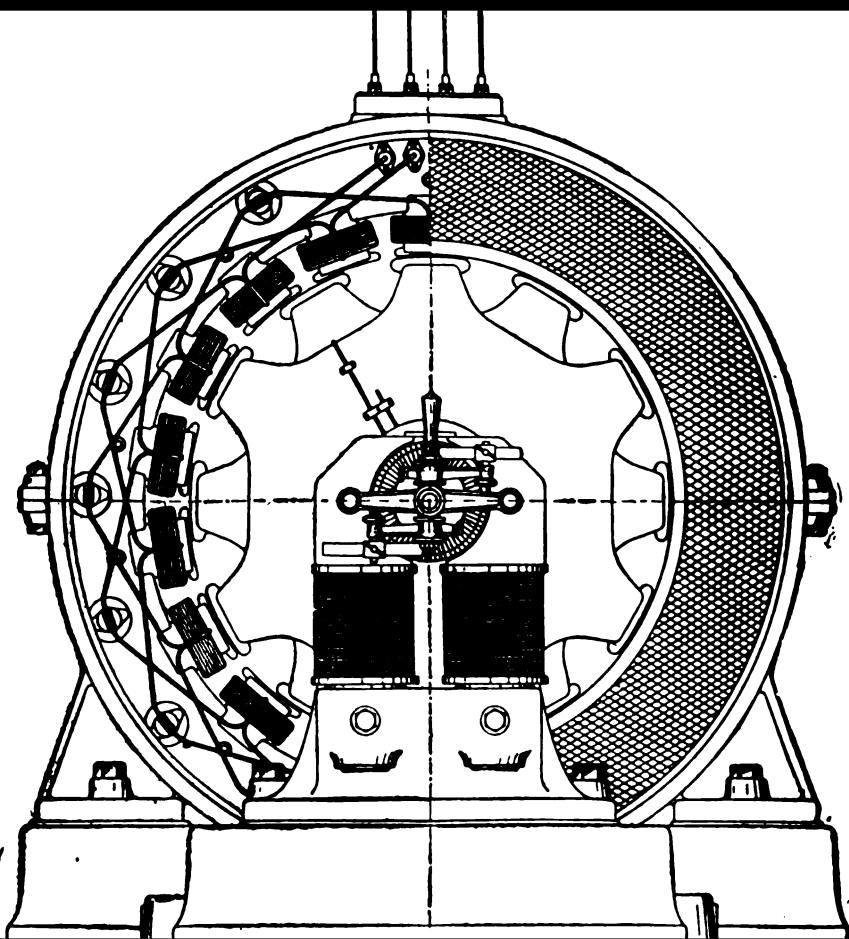
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*Engineer draughtsmen's work*

Practical draughtsman

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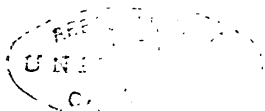
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BY A PRACTICAL DRAUGHTSMAN

ILLUSTRATIONS BY THE AUTHOR



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## PREFACE

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IN preparing this little book the author has not aimed at imparting information to the practised draughtsman, and if any such should take it up and peruse it, they might consider it trite or commonplace. On the other hand, there are a large number of aspiring young men in schools, colleges, and workshops who desire to obtain entrance into drawing offices, but are perhaps in considerable ignorance of the work carried on in such places, or of what will be required from them when there, and also of the instruments and appliances which they will need. It is to these that the author more particularly desires to address himself, and if, after they have read this book, they find that they have derived any pleasure and profit from it, he will feel that his aim has been accomplished.

*February 1896.*



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# ENGINEER DRAUGHTSMEN'S WORK

## HINTS FOR ENGINEERS

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### CHAPTER I

#### DESCRIPTION OF DRAWING INSTRUMENTS AND APPLIANCES

THERE are certain instruments, &c., which it is really necessary for a draughtsman to possess, and which he usually has to provide for himself. We will, therefore, first give a list and explanation of these, with their approximate price, and then proceed to mention others that are usually provided by the office, or which the draughtsman can gradually add to his stock as he finds the need of them.

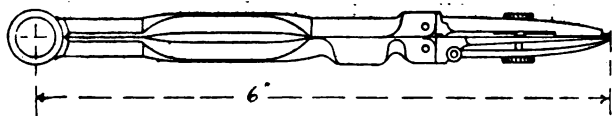


FIG. 1

First, then, to mention those things which are indispensable.

One pair of 6-inch compasses (fig. 1), double-

jointed, one leg to carry needles, the other to carry ink and pencil point only ; there are several kinds of needle-points, but the one shown in fig. 2 is a very good one.

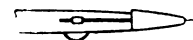


FIG. 2.—Enlarged View of Needle-point

One pair of 4- or 5-inch dividers, which may be plain, as in fig. 3, or

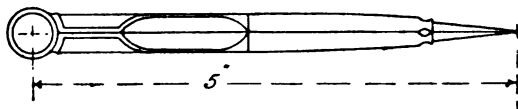


FIG. 3



FIG. 4

have a screw adjustment, as in fig. 4 ; the latter is very useful when it is required to open or close the dividers a minute distance.

One pair of 3-inch or 3½-inch pencil bows, double-jointed, with same class of needle-point in one leg as in 6-inch compasses, and one pair of ditto for ink (fig. 5).

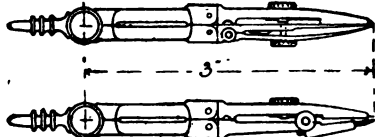


FIG. 5

Drawing pen, ivory handle, with hinged nib and thick back nib (fig. 6).

One 12-inch boxwood scale, oval section, with following scales upon it :  $\frac{1}{8}$ ,  $\frac{1}{4}$ ,  $\frac{1}{2}$ , 1,  $\frac{3}{8}$ ,  $\frac{3}{4}$ ,  $1\frac{1}{2}$ , and 3 inches.

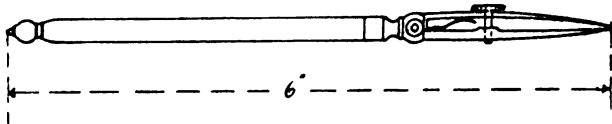


FIG. 6

One 60° set-square, and one 45° ditto ; 9 or 10 inches long is a convenient size for these, and the best for use

are those of mahogany, framed, with ebony edges (edges not to be bevelled) ; if these are too expensive,

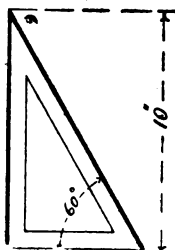


FIG. 7.—Framed 60° set-square

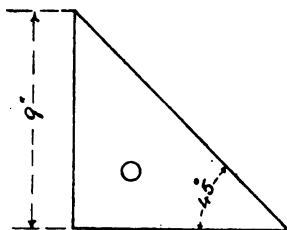


FIG. 8.—Plain 45° set-square

framed sycamore and pear-wood, ordinary pear-wood, or vulcanite ones will do very well. The vulcanite squares, however, require cleaning very frequently. A framed set-square is shown in fig. 7, and a plain one in fig. 8.

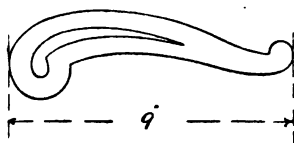


FIG. 9

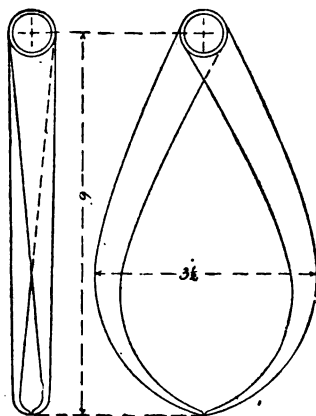


FIG. 10

One or two French curves ; the one shown in fig. 9 is a useful one, and others can be obtained as required.

A fourfold rule, 2 feet long when open and 6 inches long and 1 inch wide when closed, marked in inches and  $\frac{1}{8}$  inches on both sides, and with one 6-inch edge subdivided into  $\frac{1}{16}$  inches.

One pair of "outside" steel callipers, and one pair of "inside" callipers (fig. 10).

One protractor for reading or marking off degrees ; for ordinary work, a semi-circular horn one (fig. 11) will do, about  $4\frac{1}{2}$  inches diameter, but if for very important work a metal one more accurately divided off is better.

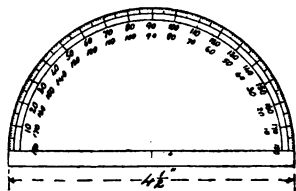


FIG. 11

A nest of saucers, fitting one into the other, and about 3 inches in diameter (fig. 12).

Two paint brushes, about "swan" or "goose" size. Sable are the best, but are expensive. Those in camel

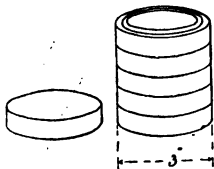


FIG. 12

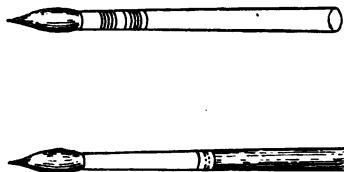


FIG. 13

hair are cheaper. They can be had in quills, or with fixed handles, as preferred (fig. 13).

Half-a-dozen drawing pins, with heads about  $\frac{1}{2}$ -inch diameter.

This completes the list of things that cannot be dispensed with, and the possessor of them will have the satisfaction of finding every one of them come in useful almost daily, instead of being saddled with a number of

superfluous instruments, some of which he may not want to use once in five years.

Taking average prices, the above outfit would cost about £4 5s. 3d., the items being as follow :

|                                                               | £  | s. | d. |
|---------------------------------------------------------------|----|----|----|
| 6-inch compasses . . . . .                                    | 1  | 10 | 0  |
| 4- or 5-inch dividers, without adjust-<br>ing screw . . . . . | 0  | 3  | 6  |
| 3- or 3½-inch pencil bows . . . . .                           | 0  | 11 | 0  |
| 3 or 3½-inch ink bows . . . . .                               | 0  | 11 | 0  |
| Drawing-pen . . . . .                                         | 0  | 4  | 6  |
| 2-foot fourfold rule . . . . .                                | 0  | 4  | 6  |
| 12-inch scale, boxwood . . . . .                              | 0  | 2  | 6  |
| Two framed set-squares, mahogany . . . . .                    | 0  | 7  | 6  |
| French curve, pear-wood . . . . .                             | 0  | 0  | 6  |
| Two pairs of callipers . . . . .                              | 0  | 4  | 6  |
| Horn protractor . . . . .                                     | 0  | 0  | 6  |
| Nest of saucers, 3 inches in diameter . . . . .               | 0  | 1  | 9  |
| Two brushes, sable . . . . .                                  | 0  | 3  | 0  |
| Six drawing pins . . . . .                                    | 0  | 0  | 6  |
|                                                               | £4 | 5  | 3  |

This total may be reduced by a few shillings by substituting pear-wood or vulcanite set-squares for those mentioned above, and probably the cost of the callipers may be saved, because in most cases men who have served their "time" in the shops generally have some by them which they have made themselves.

Having chosen one's instruments, it is a good plan to have a small neat box made to suit them, and this can be obtained for about three or four shillings, or, if preferred, a chamois leather wrap can be obtained, fitted with small loops for the instruments, and which can be folded up into a neat parcel.

We will now proceed to give a list and description

of instruments, materials, &c., used by draughtsmen which are in many cases provided by the office. All offices, however, do not have the same rules; for instance, in some the men have to find their own pencils, colours, &c., whereas in others they are found for them.

*Drawing boards.* The two most useful sizes are those suitable for "double elephant" paper and for "antiquarian" paper, the size of the D. E. paper being 40 inches by 27 inches, and the A. paper being 53 inches by 31 inches; the boards are made a little larger each way, viz. 42 inches by 29 inches and 55 inches by 33 inches. Most useful boards can be made of well-seasoned yellow pine, free from knots, ploughed and tongued, and glued together, and with battens under-

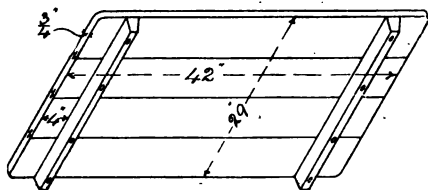


FIG. 14

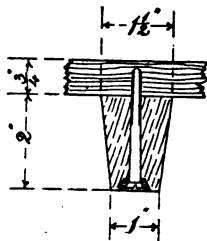


FIG. 15

neath screwed to the boards by long screws passing through slotted holes in the battens, the holes being fitted with brass slotted pieces under the screw-heads to prevent the latter chafing the wood, and to allow for contraction and expansion of the boards; the battens should be parallel in depth if the desks are sloped, but if the desks are level the battens should be tapered (see fig. 14, showing under-side of "double elephant" board, and detail section through batten, fig. 15); it is as well to glue a strip of canvas or baize under each batten to keep screw-heads or brass pieces from scratching the desks.

*Tee squares.* The best material for these to be made from is mahogany, with ebony along the working edge. But as the ebony edge makes the squares more expensive it is frequently avoided, and the squares are made of plain mahogany or even bay wood; but the drawback to these lies in the fact that the edges soon wear uneven with the constant friction of the pens and pencils, and consequently often require truing up with the plane. This involves taking the blade off the stock, and when it is replaced it often happens that the angle of the two is slightly altered, especially if the blade is simply screwed on and is not fitted with dowels. The best shape for large squares suitable for double elephant and antiquarian boards is as shown in fig. 16, and the

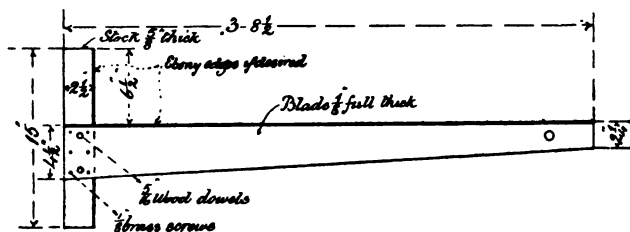


FIG. 16

dimensions will enable anyone who has time and opportunity to make one for himself.

For small work, say from Imperial size downwards, ordinary pear-wood squares will suffice, but *note* that in all cases it is best to have the blade simply put on the stock, and not to have it recessed into it, so that the set-squares can pass the edge of the board when necessary (see fig. 17).

Besides the fixed tee squares just described, there

are others with adjustable headstocks (fig. 18) to enable the blade to be set at any angle with the edge of the board ; these come in very handy when tracing from a drawing not executed by oneself, and when it is not convenient to have the square originally used, and for many other purposes.

*Scales.* There are all conceivable kinds of scales made to suit the various kinds of work from full size,

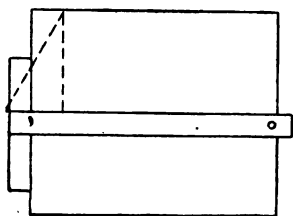


FIG. 17

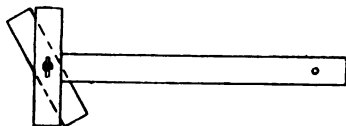


FIG. 18

or 12 inches to 1 foot, down to 1 mile to 1 inch or less. The clearest and most easily read scales, especially in the winter time, are those made in ivory, but as this material is very expensive and very subject to expansion and contraction with varying temperatures, many people prefer to use those made of boxwood. It is a good plan to have the latter French-polished, then when they get soiled they can be wiped with a damp cloth and made to look as good as new again.

*Beam compasses or trammels.* For ordinary work the best are those with open tops ; then any lath, a loose blade of a tee square, or even a thick piece of cardboard, can be used for a bar, and one trammel should be fitted with an adjusting screw, as it is very difficult indeed to set them to an exact length without. For larger and perhaps rougher work closed tops are

the best, as the trammels then require to be screwed up more securely, and if the tops are open they are liable to be strained out of their proper shape. (See fig. 19 for open, and fig. 20 for closed top trammels.)

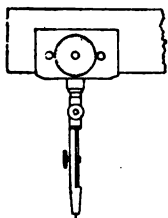


FIG. 19

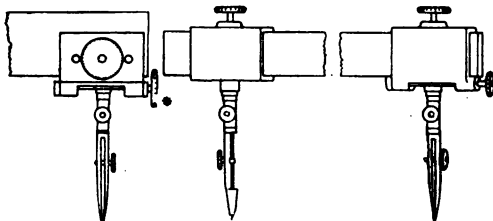


FIG. 20.—\*Adjusting Screws.

*Stencilling apparatus.* This consists of sets of plates, usually of very thin copper, in which are cut the shapes of various forms of letters and figures. They are made both plain and ornamental, and the sizes vary from  $\frac{1}{8}$  inch to 1 inch deep. They are generally used to put the titles on drawings and on various views of a drawing, and words which frequently occur, such as "fig.," "section," "plan," &c., are engraved on one plate and can be used right off; but other words have to be made up by picking the proper letters from the alphabets one at a time, and it requires care and practice to stencil a title neatly on a drawing with these. It is a good help in this case to draw a pencil line as a base for the letters, and then carefully space them the same distance apart.

A very convenient form of stencil-plate is made as follows: each letter is on a separate plate of zinc, and this is notched at each side in a line with the base of

the letter, thus enabling the operator to set each letter exactly to a pencil line ; and, further, the bottom edge of the plate is turned up with a small flange, which is a great convenience in handling it (see fig. 21).

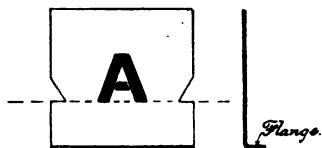


FIG. 21

Stencil plates for fancy bordering and corners are also often used.

See fig. 22 for some examples of plain and fancy letters and figures. Special ink and brushes are required, and are usually supplied with the plates, and it is necessary to



FIG. 22

have the ink of the right consistency when using it, for if it is too thick there will be a lack of sharpness in the letters, whilst, on the other hand, if too thin it will run under the plate and cause the edges of the letters to look blurred and ragged.

*Planimeter.* This is an instrument designed to measure areas on plans and drawings, and by its aid a great deal of time is saved in computing the areas of any irregular figures which will come under its range, but it takes a good deal of practice before one finds out all that can be done with the instrument. As we shall return to it later on we will leave it for the present.

*Proportional compasses.* In some special cases this is a useful instrument to aid in reducing or enlarging details on a plan or drawing. It is so marked and arranged that it can be adjusted to  $\frac{1}{2}$ ,  $\frac{1}{3}$ ,  $\frac{1}{4}$ , &c. ; but these proportions will only be correct as long as the points remain undamaged ; if one of them is injured in

the least degree the instrument becomes inaccurate. See fig. 23 for an ordinary form of the instrument.

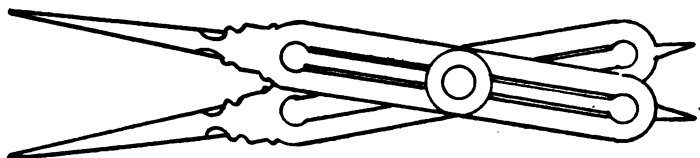


FIG. 23

*Parallel ruler.* These are made in various forms, and one of the most common is shown in fig. 24. These are all right as long as the joints do not get slack,

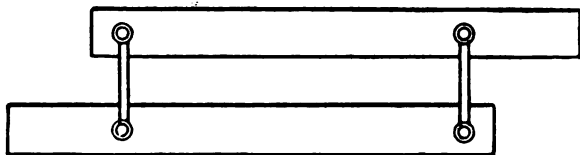


FIG. 24

but a better form is shown in fig. 25, which consists of an ebony straight-edge mounted on a pair of milled brass rollers, the latter being exactly the same diameter and both fast on one axis, so that they are obliged to move together.

*Measuring staffs.* Handy lengths for these are 5 feet and 10 feet long; the best are made of mahogany, with brass caps at the ends where the most wear takes place; the section should be about  $1\frac{1}{2}$  inches by  $\frac{5}{8}$  inches, and they should be divided into feet, inches, and  $\frac{1}{8}$  inches, the marks being stamped or cut into the wood and filled with white

C

paint. The staff itself should be polished or varnished to resist the action of damp.

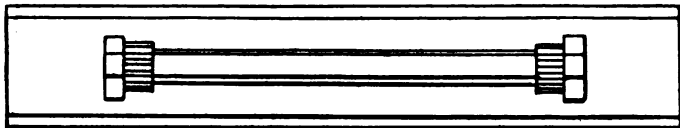


FIG. 25

*Measuring tape.* These are made in various lengths, and one of the most useful is the one 66 feet, or one chain, long. Some are of linen strengthened with fine wire woven in, and others of steel. Tapes are used for measuring up buildings and ground plans, and it is necessary to frequently test those made of linen, as they gradually stretch. A good plan is to put permanent marks in the office floor or other suitable place at intervals of 10 feet, and then the tape can be tested by these whenever necessary, and the proper corrections made on the dimensions after they are taken from the buildings or other work.

## CHAPTER II

USE AND CARE OF INSTRUMENTS, WITH HINTS ON  
PREPARING DRAWINGS

*Pencils.* For drawing lines take a moderately hard pencil, such as F or H, or No. 3 or 4, and make a rather long point of a chisel shape thus (fig. 26).

The advantages of this shaped point are that it enables the draughtsman to work close up to his squares, and that it lasts much longer than an ordinary round point; but it is a good plan to keep another pencil with a sharp round point, with which to write notes and dimensions on the drawing. Perhaps a hint on the sharpening of pencils will also not be out of place. After cutting the wood back with a sharp knife, bring the lead up to the required shape, either flat or round, by rubbing it gently on a rather smooth file, or on a

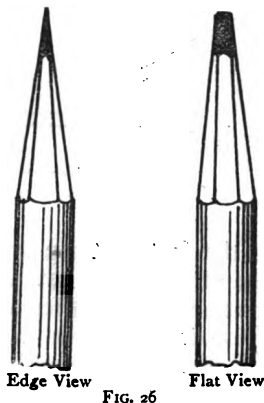


FIG. 26

piece of smooth glasspaper mounted on a handy piece of wood. Small blocks can be obtained with several layers of glasspapers arranged upon them, and as each one wears away it can be stripped off. By this means the edge of the knife will be preserved, and a much better point on the pencil will be the result.

*Drawing pen.* Most draughtsmen know the comfort of having a drawing pen which works well, and if they own three or four pens there is generally one favourite one amongst them which they use to the exclusion of the others. If the differences between them were carefully analysed, they would generally be found to consist

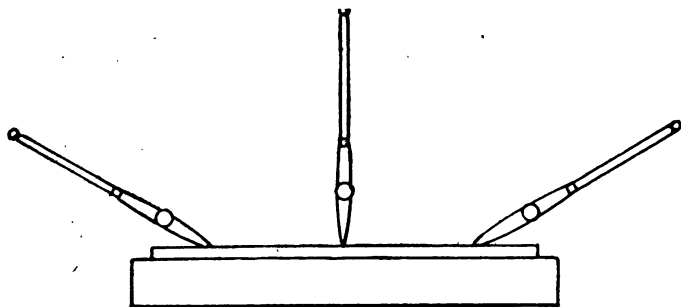


FIG. 27

in the fact that the favourite pen was "set" better than the others. To set a pen properly is rather a difficult matter, and requires a good eye and a light touch; but there is no reason why every draughtsman should not be able to accomplish it, and we will endeavour to explain the method as clearly as possible. First get the nibs into a good shape by drawing the pen to and fro along the oilstone, and at the same time rocking it over from side to side, thus (fig. 27).

After this operation the shape of the nibs should be as shown in fig. 28. Then proceed to work up each nib to a nice edge in the following manner. Begin with the pen lying as in position A in fig. 29, and gently rub to and fro, gradually raising the pen to position B, at the same time revolving the pen between the finger and thumb through nearly half a circle; keep examining the nib, and when nearly up to a sharp edge turn the pen over, and get the other nib up in the same way; then wipe the pen clean and look



FIG. 28

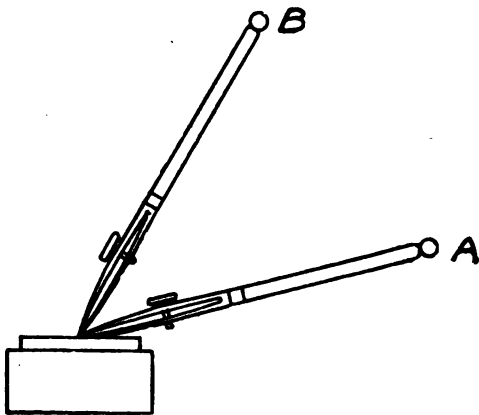


FIG. 29

right on the end of it, and if it is in good form there will be a spot of light on each nib. After thoroughly wiping off all the oil try the pen with ink for ruling thin and thick lines, and if it feels a bit scratchy get a piece of brown paper and draw the pen up and down it a few times, at the same time rocking it over, and this will

probably have the desired effect of making its action smooth.

During the whole operation of "setting" bring the nibs gently together with the screw until they just touch, and in getting each nib up separately be careful not to rub too long without examining it, or there there will be a danger of making one nib shorter than the other.

When the ink leg of the compass requires "setting," remove it from the compass, and proceed as in the case of setting the drawing pen. Having succeeded in "setting" our pen properly, we will now make a few suggestions on the proper use of it. In inking in a drawing it is generally the practice to "shade line" it—that is, to make all the lines on the top and the left-hand side of the objects thin, and those on the bottom and right-hand side thick, as in fig. 30. Theoretically this position of light and dark lines should apply to elevations, whilst those in plan should be light on the left and *bottom* and dark on the right and *top*; but it is generally the custom now to make plans and elevations all

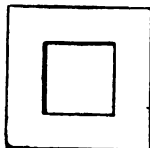


FIG. 30

alike, viz. light on the left and top. When doing the fine lines set the pen to the required fineness by trying it upon a piece of scrap paper, and do not alter the screw afterwards until all the fine lines are done, neither to fill the pen with ink nor even to clean it. To fill



FIG. 31

it, lay the nib sideways in the ink (see fig. 31) when the latter will readily flow far enough into the pen, then with a rag wipe off carefully the ink from the

outside of the pen, especially from the back nib, which comes against the squares. If the pen becomes

clogged, fold up an edge of the rag and draw it between the nibs ; if this does not suffice, dip the nib into water about three-eighths of an inch, and wipe out again with a rag. Never leave ink in the pen to become set hard, but always wipe clean after using it, and never scrape out the pen with a knife, as nothing spoils a pen sooner than that. In drawing a line do not lean the pen towards or away from yourself,

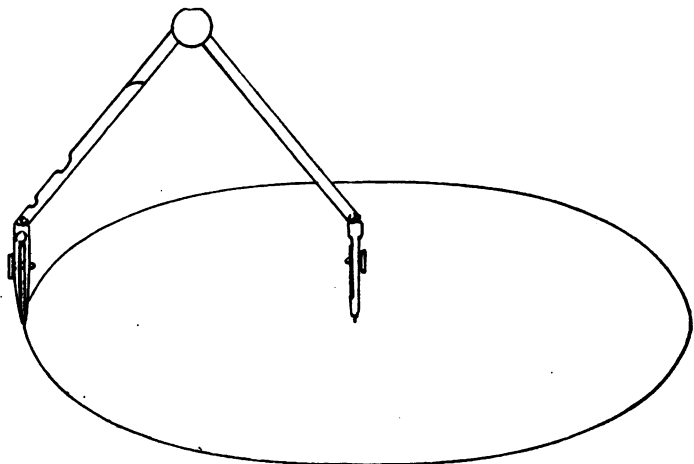


FIG. 3a

but hold it so that both nibs are equally in contact with the paper, then you will obtain a firm clear line. When drawing the thick lines, adjust the pen to the desired thickness by trial, and then do not alter the screw until all the lines are done ; by this means all the thin lines will be uniform and all the thick ones likewise. If two pens are available, of course, one may be set for the thin and the other for the thick lines. If there are any curves it is best to put them in first, as it is much easier

to join a straight line on to a curved one than to do the opposite.

In using the compasses for inking in (or for pencil-ling), keep the legs as nearly square to the paper as possible by setting the knee-joints (see fig. 32). By this means a firm solid line will be obtained, whereas

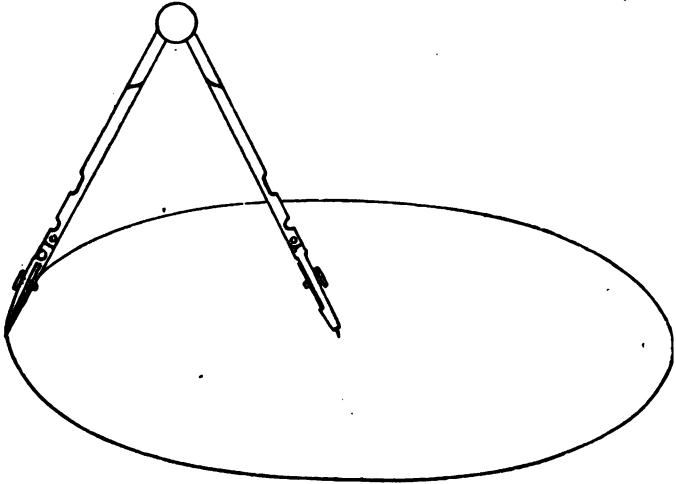


FIG. 33

if the legs are allowed to remain at an angle, as shown in fig. 33, a ragged line will be the result, and the hole in the centre will get rimmed out to a large size. To prevent the needle leg from boring through the paper some draughtsmen use horn centres, which are attached to the paper by three small needle-points; these, in their turn, deface the paper, and it is more satisfactory to dispense with their use when possible. If larger circles are required than can be struck by 6-inch com-

passes, it is better to use a pair of trammels than a lengthening bar, as the trammels are much firmer and act more squarely to their work.

Now a word as to the ink. Although there are many liquid inks in the market, and some of them appear to be of very good quality, it is still a very general custom to rub up the ink, as required, from Indian ink sticks. These are mostly of a hexagonal form, are about  $4\frac{1}{2}$  inches long, and the price is about five shillings per stick. It is often a fault with beginners that they do not get their ink black enough, possibly on account of its being a very tedious process to rub Indian ink until it is really black; but an infallible guide to its blackness is this: try a pretty thick line on a piece of paper and let it thoroughly *dry*, and if the ink is really black the line will glisten or shine in the light; if it does not present this appearance, go on rubbing. The best pans for ink are of white metal, about three inches diameter, with air-tight lids. Sometimes when using ink on tracing paper, tracing cloth, &c., there is a difficulty in making it flow well. To overcome this various means are resorted to, such as putting a little soap or ox-gall in the ink, or, instead of that, rubbing the paper or cloth over with a clean rag upon which has been placed some powdered chalk, and this last method is much the cleanest and best in our estimation.

If a drawing is to be coloured after being inked in, it is advisable to put into the Indian ink (when rubbing it up) some "indelible water." This has the effect of fixing the ink permanently, and allowing repeated washes of colour to be passed over it without disturbing it in the least. It is a good plan to leave all dimension lines and centre lines until all the colouring is done; as by this means all risk of blurring them will be avoided.

Should it become necessary to erase an ink line, which we hope will not be the case, proceed as follows : scrape the line carefully out with a sharp knife, and rub lightly with ink-eraser or indiarubber ; then take a brush of clean water and go over the erased line, and let the water remain on a short time, then blot up with clean blotting-paper ; now take a highly glazed piece

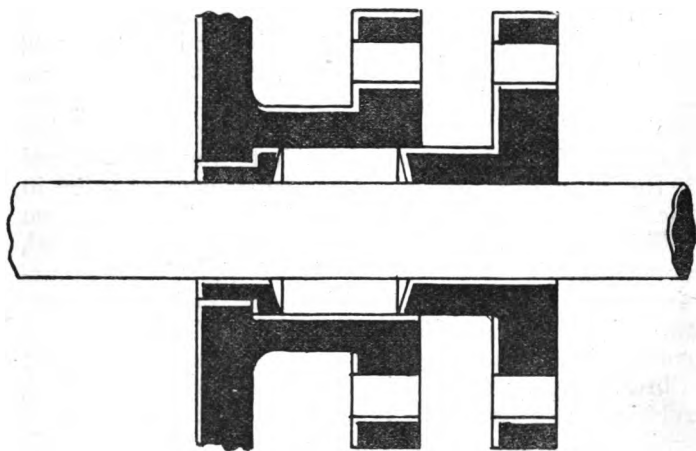


FIG. 34

of clean note or other paper and place over the line, and rub briskly on the back with a burnisher, and for the latter, if no better one is to hand, a capital one can be made out of the handle of a toothbrush. This process will partly restore the surface of the paper, but a drawing on which there has been much scratching out is

never satisfactory, as the erased surfaces all show up sooner or later.

Having inked our drawing in, let us consider a few points in relation to the sectioning and shading of it. First as regards sectioning—that is, colouring those portions of the work which are shown cut through—there are two methods usually employed and perhaps in equal favour. One is to cover the surface with solid

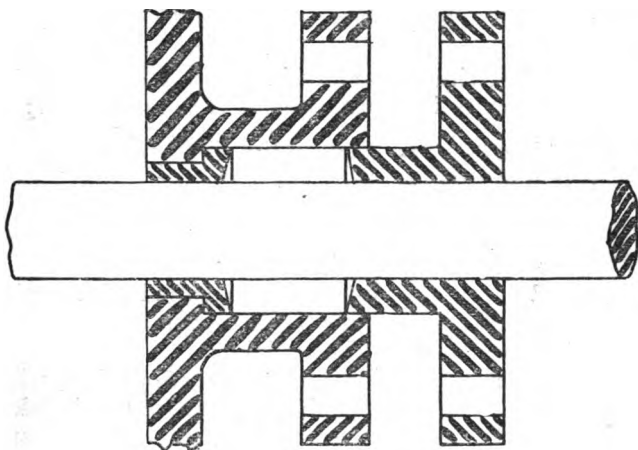


FIG. 35

colour, and when this is adopted it is best to leave a line of light along the top and left-hand edges, especially where several sections come closely together, as this helps to show the pieces more distinctly (see fig. 34). The other method of sectioning is to streak the sections with the brush, altering the angle of the streaks for

adjacent pieces, but taking care to have *all* the sections of the *same* piece of metal or other substance streaked in the same direction (see fig. 35). The streaks may vary in thickness with the size of the piece, say from lines about  $\frac{1}{32}$  inch wide to those of  $\frac{1}{4}$ -inch; these should all be done with the brush, and, if possible, at one stroke for each mark, and the angles should all be about  $45^{\circ}$ . A little practice at this will enable the draughtsman to section a drawing very expeditiously, and when well done the result is very satisfactory. Different offices have different rules and fancies for the right colours to use for various sections, but the learner may practise with the following, and afterwards will have no difficulty in adapting himself to any others :

|              |                                                                                                                               |
|--------------|-------------------------------------------------------------------------------------------------------------------------------|
| Cast iron    | = Neutral tint or Payne's grey                                                                                                |
| Wrought iron | = Prussian blue                                                                                                               |
| Steel        | = Purple                                                                                                                      |
| Copper       | = Indian red                                                                                                                  |
| Brass        | = Indian yellow                                                                                                               |
| Wood         | = Burnt sienna, varied with sepia<br>or burnt umber                                                                           |
| Brickwork    | = Crimson lake                                                                                                                |
| Concrete     | = Dots of colours stippled on with<br>point of brush, say sepia, lake,<br>and Indian yellow, each colour<br>put on separately |
| Earth        | = Sepia                                                                                                                       |

We will now consider the shading and tinting of surfaces not in section, and note that when a drawing is to be properly coloured up and shaded the ink lines must not be made thick and thin, but all of a uniform fineness; and with regard to rounded surfaces, such as piston-rods, &c., there are two methods of working them up. The first, and the best when well

done, is what may be termed the softening-off process. Suppose we wish to round up a rod as in fig. 36, we provide ourselves with two brushes; one for the colour and another for clean water. With the colour brush go down the left-hand edge, just touching the line, and before the colour is quite set take the water brush and pass it down the right-hand edge of the colour just laid on, and this will blend the colour off into the white paper; then with the water brush make a stroke down the rod, say nearly on the centre line, and before it is quite dry pass the colour brush down the right-hand edge of the water mark, and carry the colour right over to the right side of the rod; then squeeze the water brush nearly dry and pass it rapidly down the right-hand edge of the rod to take up some of the colour and to give the reflected light. Then leave the colour to dry thoroughly before touching it again, and if the colour is not strong enough repeat the process; but work as rapidly as possible so as not to rub up the original colour. The beginner may be much disgusted with the results of his first few efforts in this direction, but if he will only continue practising he will soon be able to produce good work. If after all care there should be a light place or two in the work, when it is quite dry stipple a little light colour on with the brush nearly dry, and if there should be a dark speck or two they can be toned down with a brush dipped in clean water, with the aid of a clean piece of blotting-paper.

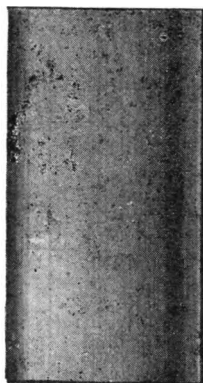


FIG. 36

The other system of shading only requires a steady

hand and a good eye for a straight line, and is much in favour with those who have a difficulty with the softening-off method. Proceed as follows : Mix a pretty dark wash of Indian ink and two washes of Prussian blue, one pale, the other medium strength. With the Indian ink go down the left-hand edge of the rod, and also down the middle of the right-hand portion, as in fig. 37, No. 1.

After this is thoroughly dry take the medium blue

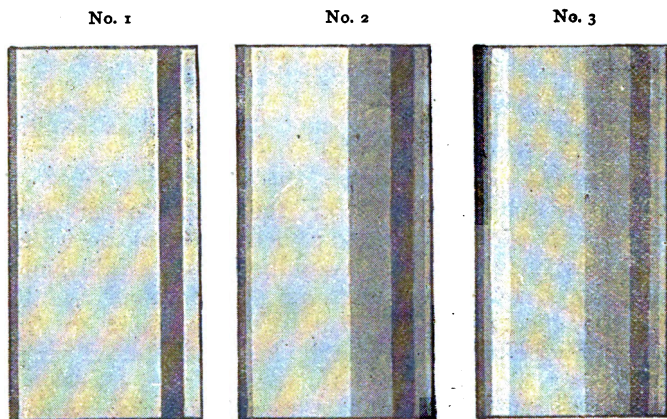


FIG. 37

wash and go over the Indian ink on the left and carry it a little farther on to the rod ; then commence just outside the other Indian ink line, and pass over it to about the same distance the other side (see fig. 37, No. 2) ; and, lastly, after this is dry, take the lightest wash, and go over the others as shown in fig. 37, No. 3.

Care must be taken to let the washes thoroughly

dry before giving the next coat ; and, when well done, the result is remarkably good considering the simple means employed. In the case we have been considering we have assumed the piece to be of wrought iron, but supposing it had been of brass we should have followed the same method, only using burnt sienna for the first dark marks and afterwards washes of Indian yellow.

In the case of the softening-off process applied to wrought iron rods, more apparent solidity can be imparted by first of all laying in a shadow of Indian ink, as in the second process, only passing the water brush down the edges to soften them off, and when this is dry proceed with the colour as described. If possible, keep a separate brush for Indian ink, as it is very difficult to get it thoroughly out of a brush when once used for it.

In colouring, the main thing is to get a good effect without labouring at it, as there is a much more brilliant effect about a drawing on which the colour has been laid on with a firm, steady hand once for all than on one which has been highly stippled and hatched, and otherwise laboured over.

In laying on flat washes, if the surfaces are small proceed to lay the tint on at once, after testing its suitability first on a piece of scrap paper. If the surface to be coloured is large, damp it all over with a large brush and clean water—avoiding going over the outline, however—and when the water has disappeared from the paper proceed to lay on the wash, commencing at the top left-hand portion and gradually working across and downwards, endeavouring at the same time not to leave one part of the wash standing longer than another. If you have a surplus of colour at the lower part of the surface squeeze the brush out and lightly take it up, but do not on any account disturb the tint laid on until

after it is thoroughly dry. Slope the board slightly towards you and use large brushes, and always run the risk of having a lot of colour left over in the palette rather than of finding yourself short in the middle of the work.

As it is often necessary to show what are termed "breaks" in a drawing, we give a few instances of some which occur pretty frequently.



FIG. 38



FIG. 39



FIG. 40



FIG. 41



FIG. 42



FIG. 43

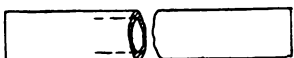


FIG. 44

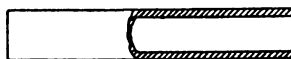


FIG. 45

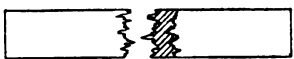


FIG. 46



FIG. 47

Figs. 38 and 39 show breaks in round rods ; fig. 40 shows a break in a square bar ; fig. 41, one in a flat bar ; fig. 42, an angle iron break ; fig. 43, a rail or H-iron break ; fig. 44, a break in a pipe ; fig. 45, the method of passing from an outside view of a pipe to a sectional view ; fig. 46, a break in a wooden beam ; and

fig. 47, a break in a wooden flooring, to show the joists underneath.

The sectional parts may be coloured suitably, or sectioned with lines, harmonising with the rest of the drawing, and note that all the horizontal lines show the true thickness of the material, even in the breaks, only those in a vertical direction being put in freehand.

If there are any dimensions to be put on the drawing, it is best to put them and the dimension and centre lines on after all the colouring is done, and the way in which this part of the work is done either adds to or detracts from the appearance of a drawing. Many a

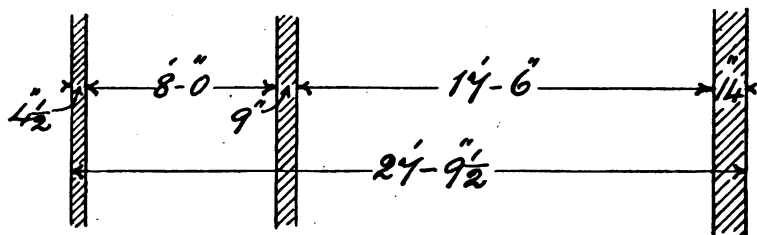


FIG. 48

decent drawing is entirely spoilt by bad writing, and by the figures being put on in a careless and slovenly manner. In placing the dimensions, it is necessary to look ahead and space them out nicely, so that there will be room for all, and not have any of them fouling each other. The dimension lines may be put in with blue or red colour, prussian blue or scarlet lake, and they may be full or dotted, and the figures should be made a fair size and be round and legible. The ticks at the ends of the lines should be made neatly, and join right up to the lines the dimensions are taken from, and as many dimensions as possible should be placed in line with

D

each other, for the sake of neatness and also because in that form they are easier to add up and to check with the overall dimensions (see fig. 48).

To make the drawing complete, it will be necessary to put a suitable title to it, and to add the scale or scales and the date; the title should be as brief as possible, and yet indicate clearly what is drawn. It may be written in plain round hand, printed by hand, or stencilled, and should be so placed that it can be readily seen if the drawings are kept in drawers. With regard to border lines and corners, such things are generally discountenanced in a practical engineer's drawing office, but they are much in favour in other offices, such as civil engineers, architects, &c., and if they are desired the neater and plainer they are the better. (See fig. 49 for an example.)

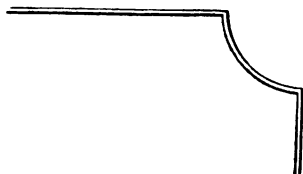


FIG. 49

To repeat a few hints in a concise form. If the drawing is a new one, and is to be shaded and coloured, ink in all lines with ink mixed with indelible water, then clean with soft rubber, or, better still, with bread. Next shade and colour, and, lastly, add dimension and centre lines, and figures and notes.

If an old drawing is to be inked in and coloured up, ink in all lines, dimensions, and ticks that are to be put in with black ink, then clean down, after which do the colouring required, and, lastly, put in red and blue dimension and centre lines.

## CHAPTER III

## FURTHER HINTS ON USE OF INSTRUMENTS

*Use of set-squares.* Anyone who can handle a pair of set-squares properly will never feel the want of a parallel ruler, and by their aid lines can be drawn parallel with each other, or at right angles with each other. To draw lines parallel with each other set one square to the first line, then place the other set-square up against it, as shown in fig. 50, and gradually slide one square against the other to the required positions of the lines, say A, B, C. At first a little difficulty may be apparent in trying to hold both squares firmly with the left hand whilst the lines are drawn with the right, but this will soon disappear with practice.

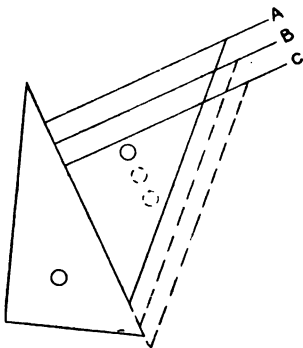


FIG. 50

To draw a line at right angles to another by set-squares, let AB (fig. 51) be the line, and place the hypotenuse of either square parallel with the line, and then bring up the other set-square against one of its other sides; hold the second square down firmly and

D

turn the first one round a quarter-turn, as shown by dotted lines; then the hypotenuse of that square will

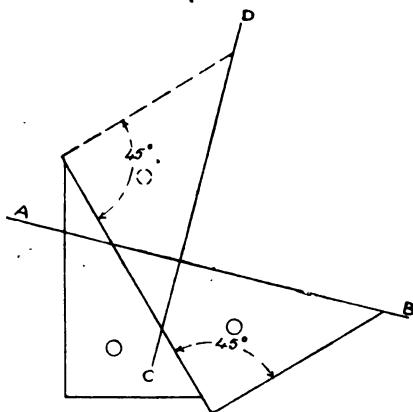


FIG. 51

be at right angles to its first position, and by its aid a line can be drawn at right angles to A B, such as C D. The only point to be observed is that the angle of the square which is rotated must be a right angle. We are supposing the squares used to be those ordinarily used, viz.  $45^\circ$  and  $60^\circ$ , and we will point out one or two more use-

ful purposes which these squares will serve. To draw the plan of a hexagonal figure, such as a nut, first determine whether you wish to show two of the sides vertical or horizontal. Suppose we assume them to be the latter. Strike a circle equal to the diameter

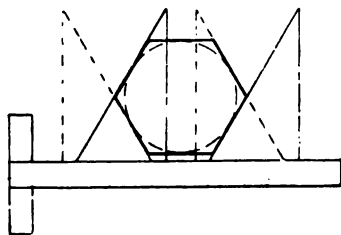


FIG. 52

of the nut over the flats; then with the tee square draw two horizontal lines tangential to the top and bottom of the circle; then place the  $60^\circ$  set-square against the tee square, and draw two more of the sides, and then turn the  $60^\circ$  set-square over and

do the last two sides (see fig. 52).

If two edges are required to stand vertically, draw the vertical lines by means of the vertical side of the set-square, and the angular lines by means of the same set-square, with the  $30^\circ$  side set against the tee square instead of the  $60^\circ$ .

*Screws and toothed wheels, &c.* A knowledge of the proper method of delineating a screw of any diameter and pitch will be found very useful, although in practical work screws are generally shown in a very conventional manner. Suppose, for example, we had to draw a single-threaded screw  $1\frac{1}{2}$  inches diameter,  $\frac{3}{8}$  inch pitch, right-handed square thread, the screw properly drawn would appear as shown in fig. 53, but to

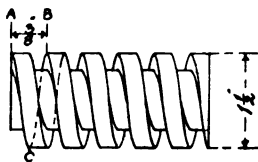


FIG. 53

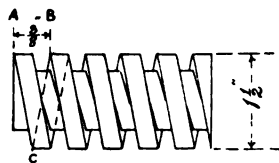


FIG. 54

save time it would probably be shown as in fig. 54. It will be observed that the pitch in both cases is marked off quite correctly, but in the second case the points of the threads are joined by straight lines; by this means much time is saved, and the drawing is just as good for all practical purposes. In marking off the threads, note that in all cases the point C should be exactly between A and B. Supposing it was a double-threaded screw we were showing, with the same strength of thread and the same diameter, it would appear as shown in fig. 55, and the pitch in this case would be  $\frac{3}{4}$  inch, as the pitch is always the distance between the edges of the *same* thread.

The threads on small bolts and studs are seldom shown in detail, but as in fig. 56.

In this example thick black lines are drawn to represent the threaded part of the bolt, and no detail or

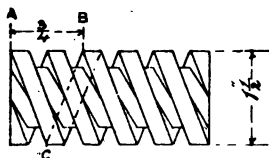


FIG. 55

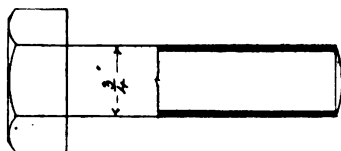


FIG. 56

particulars of the thread are given; it would, therefore, be understood to be a standard  $\frac{3}{4}$ -inch Whitworth thread, and in most offices and shops Whitworth's threads are adopted as a standard, and a table of them

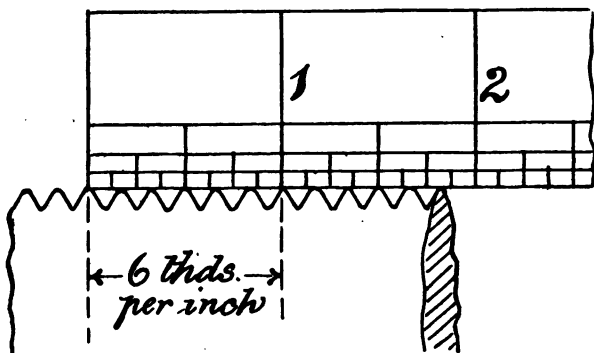


FIG. 57

containing all sizes generally used is posted up for reference. Besides giving the number of threads per inch, the table generally gives diameters of heads and nuts,

thickness of ditto, and the area in square inches at the *bottom* of the thread ; the latter item is most useful and important in calculating out the number of bolts required to hold the cover on a steam valve, cylinder, &c., as of course the bolt is no stronger than its weakest part, and that is at the bottom of the thread.

For certain classes of work, especially brass fittings, fine threads are used, and the most general are twelve and sixteen threads per inch. When taking particulars of machinery, it is often necessary to ascertain the size and number of threads per inch of various pieces of screwing, and when there is a clear inch length to work in it is easy enough to get it. Place the rule against the screw and count the threads between the inch marks—that is, the *spaces*—for observe there is always one more point between the inch marks than there are spaces (see fig. 57).

If there is not a complete inch to measure, the best plan, where possible, is to borrow two or three screwing tools and try them on the threads thus (fig. 58).

By this means the number of threads will be quickly and accurately ascertained. Of course the diameter can be obtained on outside threads by taking a measurement over the threads with a pair of outside callipers. To measure an inside thread is more difficult, but the piece which screws into it can generally be got at, and should be measured in preference.

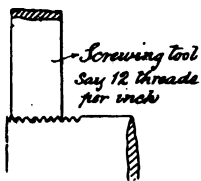


FIG. 58

Nearly all threads are spoken of as such a diameter, and this is their real diameter over the threads ; but an exception to this rule obtains in gas threads, which leads occasionally to much confusion. These threads are called by the *inside* diameter of the pipe on which the

thread is screwed *outside*. Thus, a thread marked  $\frac{3}{4}$ -inch gas would be understood to mean  $1\frac{1}{8}$  inches in diameter, and would have 14-threads per inch, and 1-inch

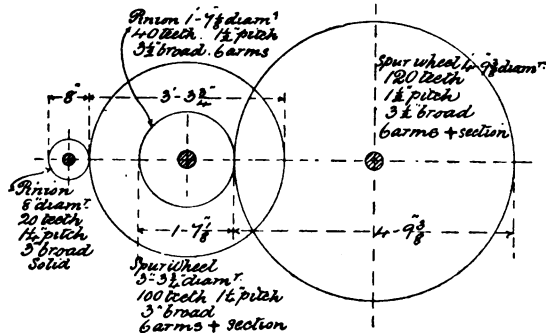


FIG. 59

gas would be  $1\frac{1}{8}$  inches, with 11 threads per inch. So it is necessary to bear this in mind.

In drawing toothed wheels, pinions, &c., it is sometimes necessary to show the form of the teeth fully; generally, however, it is sufficient to indicate by a diagram and notes what is required. Suppose, for instance, we were showing a train of wheels for a crane, we should do it in the manner shown in fig. 59. In most large works there is a collection of patterns of toothed wheels, particulars of which are tabulated and kept for reference, and of course it is the draughtsman's duty to

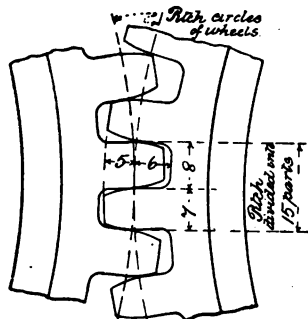


FIG. 60

bring in these patterns whenever he can, to avoid the expense of making new ones.

Volumes have been written upon toothed wheels and the various shapes of the teeth ; but unless a man is going to take up that class of work as a speciality he need not go so deeply into the subject. He should, however, have clear ideas of the meaning of the pitch diameter of the wheel, the pitch of the teeth, and the strength of a tooth necessary to transmit a certain amount of work. The circles in fig. 59 are the pitch diameters of the wheels and pinions, and should always be shown in contact, and the distance between the centres of any two wheels geared together is half the sum of their pitch diameters.

The pitch of the teeth is the distance from the edge of one tooth to the corresponding edge of the next tooth measured on the pitch line of the wheel (see fig. 60), and an approximate proportion of tooth and clearance for ordinary drawing is as follows : divide the pitch into 15 parts, then take 8 for the space and 7 for the tooth ; also make the tooth extend 5 parts beyond the pitch line and 6 parts below it, as shown.

Mitre and bevel wheels are generally shown in more

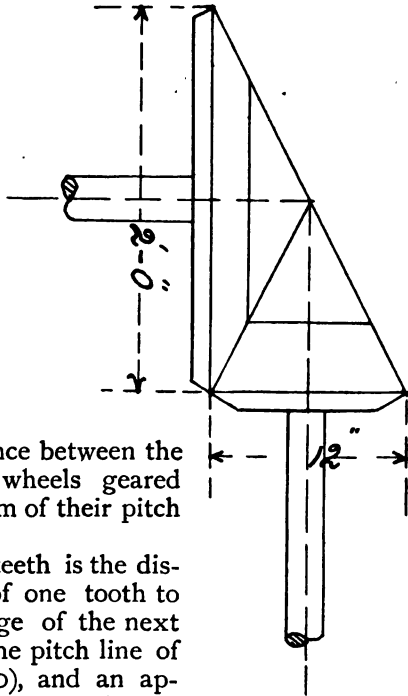


FIG. 61

or less of a diagram form (see fig. 61). In mitres both wheels, of course, are of the same diameter; but in the case of bevels the diameters may vary to almost any extent.

If the wheels are to be shown fully in detail, the draughtsman must make a special study of their forms from books on the subject, such as Unwin's "Elements of Machine Design" or Goodeve's "Elements of Mechanism."

## CHAPTER IV

## NOTES ON SKETCHING

THE draughtsman is often called upon to sketch machinery, and to obtain particulars of land and buildings situated, perhaps, many miles away. When this is the case it is very important that *all* necessary particulars should be obtained, and also that they should be *accurate*, so that a second journey is not entailed to obtain missing dimensions or to verify others.

For measuring machinery the following things are required: a 2-foot rule, a tape (useful for measuring large circumferences), a pair of inside and a pair of outside callipers, a plumb-line (if no proper one is to hand a very good one can be improvised by the aid of a piece of thread with an iron nut tied to the end); a 5-foot or 10-foot staff is also very useful sometimes, but these are awkward things to take a long way from home, and they can often be obtained on the ground; if not, a lath of some sort can be obtained, and long lengths can be marked upon that and measured off by the rule. Lastly, a note- or sketch-book is required, and a good size for this is about 7 inches by 5 inches. If the draughtsman is pretty fair at freehand sketching a book with plain leaves may be used, but if he has any difficulty in this respect one ruled in small squares in faint



on the sketch to be properly dimensioned can be drawn out a little larger on another page, and lettered or numbered for reference, such as "detail at A," and the reference letter can be put on the general view in this way: "A, see detail." In sketching leave nothing to memory, but book everything down carefully and exactly, for it often occurs that the particulars are not used for some time after they are obtained, and then it is found that there is nothing to rely upon except the particulars noted down.

### NOTES ON DESIGNING

In the case of new work being designed, a preliminary sketch or drawing is often made upon "scheming paper," which latter is a cheap thin kind of tracing paper with somewhat rough surface, to enable it to take the pencil freely; the advantage of using such paper is that it can be placed over other drawings or tracings, so that any desired parts of standard work, &c., may be traced directly instead of having to be drawn by scale. When the design is approved of, it is then drawn properly to scale upon mounted or other drawing paper. A general arrangement of the work, engine, machine, or whatever it is, is drawn upon one sheet to a suitable scale, perhaps 1 inch or  $1\frac{1}{2}$  inches to 1 foot, and the details are drawn out on other sheets, the wrought-iron work on one, the castings on another; so that tracings can be taken off each, and sent to the smith's shop and the pattern shop respectively. The details should be drawn as large as convenient, small and intricate parts being shown full size, simpler pieces to 3-inch scale, or half full size. The edges of all the machined work (in the detailed drawings and tracings) should be coloured with red or some other tint, so that

the shop foremen can tell at a glance where metal must be left on the castings and forgings to clean up to the finished sizes. These red lines may be run round the edges of the work either with a fine brush or with a drawing pen, and a note is added to say "machine surfaces tinted red." Before any drawings or tracings go into the shops, all the dimensions, &c., are checked by the chief draughtsman, or by some leading man in the drawing office.

In designing machinery it is necessary that the draughtsman should understand the relative strengths of the materials which he has to use, and the various purposes to which the materials should be applied. Thus, wrought iron is rather stronger in tension than in compression; therefore, if used for a girder the top or compression flange would be made rather thicker than the bottom one. Again, wrought iron being easily forged, it is used for all sorts of rods, levers, axles, &c. Steel, both forged and cast, is better in compression than in tension; but in both respects it is stronger than wrought iron, and is therefore largely used where great strength combined with lightness is required. It is used for rails, boilers, girders, shafts, connecting and coupling rods, &c.; in its forged or rolled forms, and in the form of castings for wheels, brackets, machine frames, &c. Brass is a comparatively soft metal, but being non-corrodible is used very much where likely to come into contact with water, such as for valve casings, valves, seatings, &c.; it is used, also, in many bearings for axles and shafting, as it and iron or steel run well together if properly lubricated, whereas wrought iron will not run with wrought iron or steel with steel. Phosphor bronze is now largely used instead of brass for bearings which are subjected to heavy loads, also for slide valves, &c. In cases where it is necessary for strength to have steel and

steel running together, a thin lining of white metal must be sweated on one piece, and be renewed as it wears away. Cast iron is much more favourable in compression than in tension, its latter quality being very low and not to be much relied on ; but, being cheap, it is generally used where weight is required and where its compressive strength is useful, such as in heavy bed plates for engines, tools, &c. In designing large castings, several points require attention ; one is to make all the metal as uniform in thickness as possible—that is, do not change a thickness of, say, 2 inches to  $\frac{1}{2}$  inch, but where a change of thickness is unavoidable put in a good fillet in the corners and make the metal taper gradually, otherwise the casting will most likely crack in the cooling. Suppose, for example, a cast-iron girder is in question (see fig. 63). On account of the metal's superior qualities in compression, the top flange is made much smaller and thinner than the bottom one, but

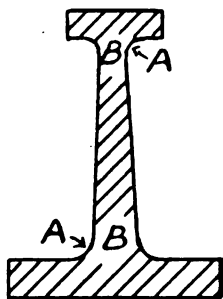


FIG. 63

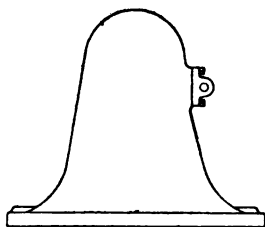


FIG. 64

large fillets should be put in at A, A, and the metal should be tapered in the web as shown at B, B. Also do not make small niggling projections on large castings, as they are liable to breakage, but rather

make suitable facings on the castings, and bolt such things as small brackets to them (see fig. 64). Also in small castings, endeavour to make them as simple as possible, so that the "core box," if any, will not be too complicated, and there will not be a number of "loose pieces" on the pattern to bother the pattern-maker. This is a point where a little experience in the pattern shop stands a draughtsman in good stead.

### FACTOR OF SAFETY

This is a very familiar term to a draughtsman, he being frequently asked as to some piece of machinery which he is designing, what factor of safety has it? The term means this, that supposing you are designing a boiler to carry 150 lbs. steam pressure per square inch, you would make it so that it would require five times that pressure, or 750 lbs. per square inch, to burst it, in which case you would say that the boiler had a factor of safety of five. This excess of strength has been found necessary from experience to cover such contingencies as unexpected failure of material, imperfect workmanship, and, above all, to make allowance for the corrosion and consequent weakening of the plates from use and age. In the case of a boiler, it would be expected to last, say, about thirty years, although, probably, before the end of that time the working pressure of 150 lbs. might have to be somewhat reduced.

Factors of safety vary according to the nature of the work and the shocks which may come upon it; thus, in the case of a girder carrying a dead load—that is, one which is constant—a factor of three times might be considered sufficient; whilst, on the other hand, in the case of a crane liable to jerks and sudden strains, a factor of ten times might not be considered too liberal.

## CHAPTER V

## LEVELLING AND SURVEYING

THE principal instruments ordinarily used in surveying and levelling are the following :

*The theodolite*, of which instrument there are several varieties, the most perfect of them being perhaps that called the transit theodolite.

*The level*. There are also several varieties of this instrument, viz., the Dumpy level, Troughton's level, and others. Both the above instruments are expensive, an ordinary theodolite costing about 25*l.* or 30*l.*, and a level, say, from 15*l.* to 20*l.* They should, therefore, only be purchased after carefully considering the work they are likely to be required for, and on the advice of someone who has had a good deal of practical experience with them. For a very complete and useful description of these instruments see Stanley's "Surveying Instruments."

*The cross-staff*. This is a useful little instrument for setting off right angles, and angles of 45 deg., from any point in a line. It is a small hollow metal box, having eight sides; in each of these there are slots, two of which have wires fitted to them to aid in setting the instrument. It is placed upon a short staff (see fig. 65), fixed firmly in the ground at the point from which the right angle is required. A pole is then placed upon the base line some distance away, and the cross-staff adjusted so that one of the wires intersects it. A sight is then taken through the slots at right angles to this whilst an assistant places a pole until it is intersected by the second wire. Of course, the result is only

E

approximately correct, and the cross-staff should therefore not be used where great accuracy is required.

*The levelling staff.* This is generally of mahogany, and in length varies from about 14 feet to 18 feet. For convenience of handling and carriage, it is usually made of a telescopic form in about three pieces, to slide one within the other. The staff is marked as plainly as possible in feet and decimals of a foot, each foot being divided into ten parts, and each part subdivided into ten again.

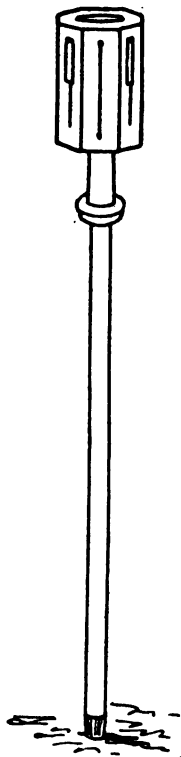


FIG. 65

*The chain.* The length of this is  $\frac{1}{80}$  of a mile, or 66 feet. It is generally made of stout iron wire with one long and three short rings alternately, and is divided into 100 links, every ten of these being marked by a piece of brass. With constant use the chain is liable to stretch; it must, therefore, be regularly examined and compared with some length permanently fixed on a floor, or with a chain specially kept for a standard and not otherwise used. Ten iron arrows always accompany the chain, to be used for marking the points on the ground from which the measurements are taken; two men usually handle the chain, and the leader takes all the arrows at first and keeps planting them at each fresh measurement, and as the second man moves forward he takes them up until they all come into his possession, at which

time the line measured will be ten chains long. When this has taken place he hands them all to the first man again, and they proceed as before.

Surveying may be defined as the art of obtaining the exact shape of a piece of land, and may vary from a simple matter like the measuring of a plot of land suitable for the site of a humble cottage to the gigantic operation of measuring the whole of the British Isles, called the ordnance survey, which has been going on for years and is still in progress.

The scales upon which the ordnance surveys are made are as follows :

Towns of 4,000 inhabitants or over,  $\frac{1}{800}$  = to 126'72 inches to 1 mile, or  $41\frac{2}{3}$  feet to 1 inch.

Parishes in cultivated districts,  $\frac{1}{3800}$  = to 25'344 inches to 1 mile, or 1 square inch to 1 acre.

Counties, 6 inches to 1 mile.

The kingdom, 1 inch to 1 mile.

Levelling is a necessary accompaniment to surveying, as, besides requiring to know the shape of a piece of land in plan, we often want to know its level, to find if it is above or below certain other points, and to see if any excavation will be required or if any embankments will have to be made, as in the case of surveying for a line of railway.

The principle of surveying consists in laying out as long a straight line as possible on the ground to be surveyed, and upon this line constructing one or more triangles, and from the sides of these triangles taking various offsets or measurements to the boundary of the land. These lines and triangles are carefully noted in a book on the ground, with all necessary dimensions, and are afterwards plotted or drawn down to a scale on paper, and when the boundaries, buildings, and fences are correctly located, the triangles, of course, can be rubbed out if required.

The highest class of surveying is done with the theodolite, a most perfect and beautiful instrument, and by the aid of which the utmost accuracy may be attained. It is a matter of time and care to set up and adjust the instrument properly. It is, therefore, generally used on important work, and is fixed at points from which a number of readings can be taken at one setting. By its aid angles can be read off, both vertically and horizontally.

Ordinary surveying may be done with a chain or a tape, and a cross-staff or large square for laying off lines at right angles to others. It is handy to remember that if the sides of a square are laid off in the proportion of 3, 4, and 5, that they give us a right-angled triangle, so that by the aid of a tape or chain alone we can always set off a right angle. Thus, suppose we wish to lay off a right angle to A, B, at point C, fig. 72. On either side of point C mark off a distance equal to 3 yards or 3 feet at D, and from C set off also a length equal to 4 yards or feet at E, and if length between D and E equals 5 yards or feet, the angle DCE will be a right angle. Of course this is founded on the fact of the hypotenuse of a right-angled triangle being equal to the square root of the sum of the squares of its two sides. Thus,  $4 \times 4 + 3 \times 3 = 25$ , and the square root of  $25 = 5$ . The branches of study most advisable for

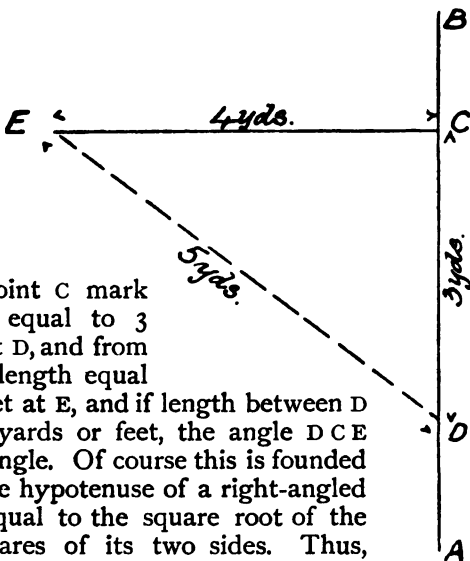


FIG. 66

those entering on this class of work are geometry, plane and solid, euclid, mensuration, logarithms, decimal fractions, trigonometry, and algebra ; also practise drawing plans from one's own measurements, and making copies of good examples, paying special attention to the style, colouring, &c., of the latter, and obtain as much practical acquaintance as possible with the instruments out of doors by joining some class in surveying, such as are now held in large towns like London, Manchester, and others. If it is not always convenient to go out with the level or theodolite, take a tape or chain, and, with a friend to help, measure up any field or odd piece of land, with any buildings or what not upon them, and try to plot the result down on paper at home to some suitable scale, such as 2 chains to the inch, and you will soon find yourself progressing in the right direction.

Before leaving this subject we may refer briefly to hydrography, or map drawing. The hydrographer proper is concerned chiefly with maps of the coast-lines, islands, and shoals, which are made for the benefit of mariners and others, the office being a Government one under control of the Admiralty. Ordinary map drawing may be all in black lines, with the hills, &c., shaded in Indian ink with a brush or by a hand-pen so graduated as to show the various heights and hollows of the ground, or it may be coloured to represent the various parts naturally, in which case the man who has taste and a knowledge of landscape painting will have a great advantage. Neat printing and bordering are especially necessary in this work.

### ESTIMATING

This is a class of work which a draughtsman is often called upon to perform, and, besides requiring great care, puts his arithmetical knowledge to the test

also—one estimate perhaps demanding the use of mensuration, practice, compound addition, and interest.

If an estimate were required for the cost of some machinery not yet made, all the quantities of the various metals would have to be calculated out from the drawings by first obtaining their cubic contents, and then multiplying each in turn by the weight per cubic inch or foot for each particular metal. Then these weights would be taken at so much a cwt. or ton, according to whether they were rough or machined.

Additions are often made to estimates, such as the following: Cost of erection, office charges on labour, and extra for unforeseen contingencies.

In some cases the draughtsman completes the estimate, but in others he gets out the quantities only, and the prices are put on by another department.

We herewith give a sample estimate to show the general form which is used. The various items and prices, however, are only assumed, the latter varying largely with different firms and in different districts. (See p. 55.)

In estimating for buildings there are innumerable details to be considered, such as excavation, concrete, brickwork, roofing, joiners', plumbers', and plasterers' work, and there are special methods of measuring many of the details, which can be obtained from Hurst's "Pocket-book" and other works.

#### INDICATING STEAM AND OTHER ENGINES

A draughtsman is often called upon to perform the above work; it is, therefore, advisable to be in some measure prepared for it. Engines are indicated for two reasons: either to obtain the horse-power which they are developing, or to enable one to judge if the valve is set and acting properly; the latter fact can be ascertained at once by examining an indicator-diagram, as it shows

**THE GENERAL ENGINEERING COMPANY, LIMITED**  
**Estimated Cost of 14-inch Accumulator**

Enquiring No. ....  
Tracing No. ....  
Specification No. ....  
Date .....

|           |    |   |    |    |   |   |   |    |   |    |    |    |
|-----------|----|---|----|----|---|---|---|----|---|----|----|----|
| <i>d.</i> | 0  | 0 | 4  | 0  | 0 | 0 | 0 | 0  | 0 | 0  | 0  | 0  |
| <i>s.</i> | 10 | 0 | 8  | 10 | 0 | 0 | 0 | 8  | 0 | 0  | 10 | 0  |
| <i>h.</i> | 16 | 8 | 18 | 24 | 7 | 6 | 4 | 10 | 9 | 30 | 22 | 10 |

|     |   |     |
|-----|---|-----|
| 301 | 6 | 4   |
| 30  | 2 | 7½  |
| 331 | 8 | 11½ |

whether the "lead" is correct, whether the "cut off" is the right percentage of the stroke, and whether the exhaust closes at the proper point.

To ascertain the horse-power of, say, a two-cylinder engine, diagrams should be taken simultaneously from both ends of a cylinder, then the horse-power of each diagram should be worked out, the two added together, and that total multiplied by two for the two cylinders

The horse-power of one diagram would be  $\frac{A P R S}{33,000}$ ,

where  $A$  = area of piston in square inches,

$P$  = mean pressure of steam in lbs. per sq. in.,

$R$  = number of revolutions per minute,

$S$  = stroke in feet.

The mean pressure of the steam in lbs. per square inch in the cylinder is obtained by dividing the diagram into ten parts, and measuring the ordinates with the scale of the diagram, then adding all these together and dividing by ten. See fig. 67, showing a diagram from

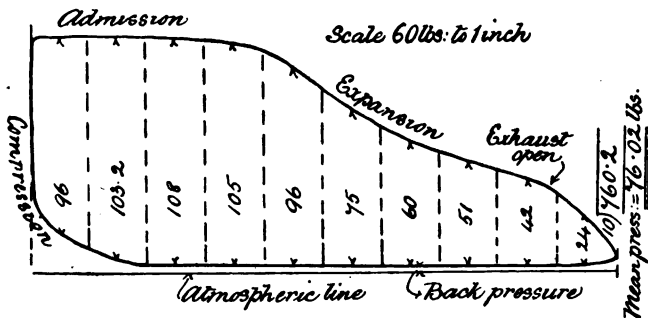


FIG. 67

an actual engine, with the ordinates, mean pressure, and the action of the steam noted.



## CHAPTER VI

BRANCHES OF SCIENTIFIC KNOWLEDGE ADVISABLE  
TO BE STUDIED BY DRAUGHTSMEN

FOR those likely to be engaged upon general engineering work, in the first place they cannot be too well up in arithmetic, and they should pay special attention to decimals and decimal fractions, as nearly all calculations are worked by these rules, as we will more particularly point out presently. If they are acquainted with algebra so much the better ; but this is not absolutely necessary, as when there are extra abstruse calculations to be made they are generally referred to one or two men who may happen to be well up in that line—in fact, some offices keep a calculator, who is expected to solve problems as they arise. It does not always appear that the best theoretical men make the best draughtsmen. Many of the best and most useful men have been obtained by taking into the office intelligent young fellows who have served their time practically in the shops, including experience in the pattern shop if possible, and who have studied in the evenings at a good technical school or mechanics' institution to perfect themselves in arithmetic, drawing, and different branches of science, especially mechanics and steam, and in drawing plane and solid geometry development of surfaces, and projection of shadows. With regard to solid geometry, we do not mean to say that a man need know as much even as is expected of him to pass a second-grade advanced examination, but

that he should work more on the lines of what is called orthographic projection—that is, take some simple geometrical figure, such as a cube or a hexagonal pyramid, or a mechanical figure, such as a nut or a wheel, and draw it in all possible positions, as shown in fig. 69.

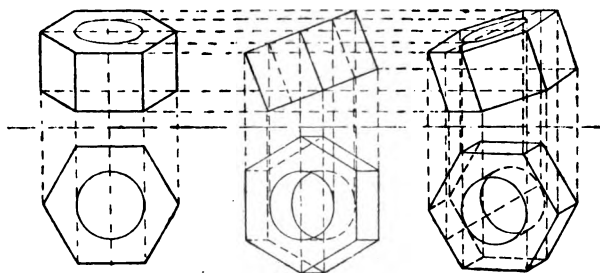


FIG. 69

By mastering the principles involved in the above, and similar examples, the student will render himself able to project any work in any mechanical or other drawing that may be given him to do.

The development of surfaces comes in very useful sometimes in boiler work, when it is requisite to know the proper size and shape of a plate in the flat which will work up to a certain curved form, such as plate A in the hemispherical end of a boiler (see fig. 70), or in a ship's buoy, &c.

Projection of shadows is a very useful study, as it enables one to correctly shade up a finished drawing, but it is a study much neglected as a rule, and the consequence is that when a drawing has to be shaded up it is often done in a very unsatisfactory way.

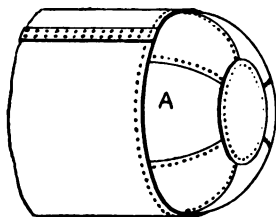


FIG. 70

Even if only a little shading is required, that little looks much better when put on in the right way, and the man who has studied the subject can often tell at a glance how and where to place the shadows without troubling to mark them out, first, geometrically. For instance, if we wish to shade up a round rod, by drawing a circle to represent a plan of the rod and two lines at an angle of  $45^\circ$ , one to the centre and one tangential to the rod, we find at once the position of the highest light and the deepest shade upon the rod, see fig. 71, and work accordingly.

Also, suppose we wish to cast the shadow of a blocking course, &c., on the elevation of a house. By making a profile view of the moulding, and drawing lines at  $45^\circ$  from each projection on to the next face below, we at once find the depth of the shadow (see fig. 72).

Referring to the sciences which a draughtsman should study, we may safely say that mechanics, both theoretical and applied, is one of the most important of them. A man is constantly confronted with problems in this science, whether he be designing engines, cranes, tools, or girders. If, for instance, he is designing a crane to lift a certain load, say, a 10-ton hand crane, he must be able to calculate the transverse strain on the crane post, the tension on the tie rods, and the compression upon the jib. He must also be able to so arrange the gearing that the power applied, say, by four men at the handles exerting 15 lbs. each, will lift the required load of 10 tons.

The science of steam is also extremely useful, especially to men engaged upon engine and boiler work. If a man were engaged in designing a compound engine he should be prepared to say what the steam pressures would be at the end of the stroke in the high pressure cylinder ; in the receiver, if there was one, between the

high-pressure and the low-pressure cylinders ; and on the entrance to and exit from the low-pressure cylinder, and he should be able to construct an approximately correct indicator-diagram for the two cylinders. Also he would require to so proportion the cylinders that they should, as nearly as possible, each perform the same amount of work.

Last, but not least, returning to the question of calculations, nearly all these can be done by decimals ; for instance, it is often necessary to work out the weight

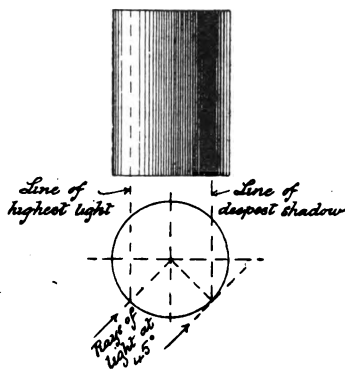


FIG. 71

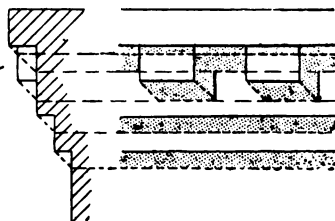


FIG. 72

of machinery, boilers, &c., from drawings, in which case we should proceed to find the cubic contents of the work as follows : Take the dimensions of each piece, or portion of a piece, if necessary, in feet and inches, and then turn them all into inches and decimals of an inch by means of a table of decimal equivalents ; then by multiplying these together we should obtain the number of cubic inches in the piece. Suppose the article is cast iron. We find from the table in Molesworth's pocket-book that this weighs .26 lb. per cubic inch ;

we therefore multiply the number of cubic inches by '26, and thus get the weight in lbs. If necessary we then divide the weight in lbs. by 2,240, 112, and 28 to turn it into tons, cwts., qrs., and lbs. And as there is a different factor for the weight of a cubic inch of various materials, it is necessary to keep the cubic inches of cast iron separate from those of the wrought iron, and these in their turn from the steel or brass. The multiplier for wrought iron would be '28 lb. per cubic inch, for steel '288, and for brass about '3.

We may have to find the number of square feet of plate in a boiler, in which case we should take our lengths, circumferences, &c., in feet and inches, turn all the dimensions into feet and decimals of a foot; then multiply them together and obtain the answer in square feet and decimals of a square foot. Supposing, then, we had to give the weight of these plates, we should look in the table for the thickness of the plate we were using, and if it was  $\frac{1}{2}$ -inch steel plate, say, the multiplier would be 20'8 lbs. per square foot. We should, therefore, multiply this factor by the number of square feet (if they were all  $\frac{1}{2}$ -inch plates), and thus obtain the weight. If the shell plates differed in thickness from the flue or end plates, we should find the number of square feet of each thickness separately, and multiply each in turn by its own factor, and then add all the weights together for the total weight.

We have incidentally referred to Molesworth's pocket-book, which is a most useful aid to the draughtsman, containing, as it does, so many valuable tables and formulæ for his assistance. If one is well acquainted with the various tables in this and other books, a wonderful amount of work may be saved. For example, it is never necessary to obtain the area of a circle by squaring its diameter and multiplying by '7854, as we have only to consult the table to find it all done for

us from  $\frac{1}{8}$ -inch up to 100 inches diameter, advancing by  $\frac{1}{8}$ ths and  $\frac{1}{10}$ ths all the way. The same with squares and square root, and cubes and cube root.

Suppose we want to find the cubic capacity of a cylinder 21 inches diameter and 30 inches stroke, we look in the table for area of 21 inches, which equals 346.3 square inches, and then multiply this figure by 30 inches, which gives us the capacity in cubic inches ; if we want the capacity in cubic feet, we divide this number by 1,728, being the number of cubic inches in a cubic foot.

Or if we are dealing with circular figures, of which the superficial area is required, such as a boiler shell 4 feet diameter and 10 feet long. To find the circumference, we should not trouble to work it out by multiplying 4 by 3.1416, but look in the table of circumferences, and opposite 4 we should find 12.56. We should, therefore, take 12.56 and multiply it by 10, and obtain 125.6 square feet, the superficial surface of the shell.

## CHAPTER VII

PREPARATION FOR DRAUGHTSMEN ENGAGED IN  
VARIOUS BRANCHES OF WORK

*Roof, Bridge, and Girder Work.* With this class of work in view a man should study mechanics, especially the composition and resolution of forces, as problems constantly arise relative to the stresses on the booms and lattice bars of girders, and in the ties and struts of roof principals. He must study the weight likely to come upon the structures by such agencies as the wind and snow, besides that of the special loads the structures are designed to carry. It is also necessary to have a good knowledge of the strength of materials, especially steel and wrought and cast iron, and to study all kinds of fastenings for plates, bars, angles, tees, &c., so that the necessary strength can be obtained with due economy of material. The question of expansion and contraction of metals is also very important, as these have to be allowed for in all large structures by means of roller bearings or other devices.

The stresses in the various members of a girder or roof truss can be calculated, or they can be found by means of "graphic statics," the latter method having come much into use of late years. It consists of drawing diagrams to a certain scale of the load on the drawing of the girder or truss itself in such a way that the stresses on the various members can be read off directly by a scale without calculation.

"Graphic statics" can also be used for many other purposes, such, for instance, as finding the bending moments in an axle, or the stress on the crankpin of an engine at various points of the stroke.

In constructing girders or principals, it must be borne in mind that the structures have to carry their own weight in addition to any extraneous load ; and in the first place this weight has to be assumed and added to the load which the girder or other structure is being designed to carry. This assumed weight can sometimes be approximated from the known weight of other structures doing similar work ; but after the girder has been roughed out the weight can again be checked over, and the total load corrected as required before finally finishing the drawing. Girders are usually built with a camber—that is, slightly hog-backed, or higher at the middle than at the ends. This is done to counteract the slight sag which takes place when the girder is in position and the load comes upon it, and the camber should equal the calculated deflection of the girder. As a rough guide we may say that a girder 40 feet long would have about 1 inch of camber. The amount of camber is noted on the drawing, but the drawing itself is of course made straight. All plates should be kept as uniform in thickness as may be, all tees and angles as uniform in section as possible, and for ordinary work  $\frac{3}{4}$ -inch rivets about 4-inch pitch should be used.

*Hydraulic engineering.* In addition to mechanics, study hydraulics and hydrostatics ; also the strength of materials, especially of cast iron and cast steel, these being most commonly used for the cylinders of hydraulic machines and tools. Steel is generally used for the very high pressures which obtain in these days, amounting in some cases to 5 tons per square inch. For these high pressures cast iron is not suitable, as, to obtain the

requisite strength, the metal has to be made so thick that it sometimes becomes unsound through its own contraction in cooling.

The water pressure for working hydraulic machinery, such as cranes, lifts, rivetters, and presses, is generally obtained with the following plant: an accumulator worked by pumping engine, or by pumps driven from gearing. The accumulator serves the purpose of a fly wheel on a steam engine, viz. to store the power until required. It is usually a cylinder about 17 feet long and 17 inches in diameter, with a heavy weight on the ram sufficient to give the pressure required per square inch, in some cases 700 lbs. The accumulator should be of such a capacity that when the maximum number of machines are drawing water from it the ram should not be at the bottom of the cylinder.

In cranes and hoists the stroke of the cylinder is frequently only a tenth or twelfth of that of the load; therefore, supposing a weight of 30 cwts. had to be lifted, the cylinder would have to be equal to ten or twelve times that weight—that is, 15 or 18 tons—and beyond this there would have to be a large allowance made for friction caused by the extra gearing, besides that from the packing.

*Electrical work.* To render himself efficient in this class of work we would recommend a man to train himself as far as possible, as follows: In mathematics at least up to second stage in Science and Art examination. Steam, mechanics, theoretical and applied, and solids and fluids. Magnetism and electricity; dynamos, design, and construction; electrical testing, sound, light, and heat; machine drawing, solid geometry; and, if possible, building construction; which, although not really essential, will come in very handy sometimes. It is also very advisable to have had a good mechanical

shop training. This last point is one considerably neglected, and, in consequence, there can be found plenty of smart young theoretical electricians who are short of practical mechanical knowledge.

*Marine engineering and shipbuilding.* A youth entering the drawing office in either of the above departments should be well grounded in arithmetic, and for marine engineering work should have previously had a year or two in the fitting, erecting, and pattern shops, and also, if possible, have had a voyage or two at sea on the engineer's staff.

For shipbuilding he should have spent a year or two in the plating, smithy, moulding, and pattern shops. This preliminary training in the shops gives practical acquaintance with materials, tools, and technical terms.

Whilst working in the shops, evening classes should be attended in mechanical and freehand drawing, elementary algebra, mechanics, hydraulics, pneumatics, and mensuration. After entering the drawing office studies should be continued in advanced work in above subjects, and in addition weights and strengths of materials and graphic statics should be taken up, also, for marine engineering, heat and steam, and for shipbuilding, mensuration of solids, conic sections, and calculations of displacement, centres of gravity, and metacentre.

In marine engine drawing, boards generally used are double elephant and antiquarian, and the general arrangement of the engines and boilers is drawn to as large a scale as the boards will admit, such as  $\frac{3}{4}$  inch, 1 inch, or  $1\frac{1}{2}$  inches to 1 foot.

In shipbuilding drawing, the smallest boards are double elephant size, whilst there are larger ones that run to 15 feet or more. The lines and general working drawings of large vessels are usually drawn  $\frac{1}{4}$  inch to

1 foot ; rigging plans to  $\frac{1}{8}$  inch to 1 foot ; and detail  $\frac{1}{8}$  inch,  $\frac{3}{4}$  inch, 1 inch,  $1\frac{1}{2}$  inches, 3 inches, and 6 inches to 1 foot, and full size, as their importance requires.

Cloth tracings, photo. prints, and sometimes hand sketches are sent into the shop to be worked to ; but the original drawings are often kept in pencil until the work is complete, and then checked over and altered where necessary and inked in. One awkward feature of this arrangement is that the boards are practically locked up for months, or even a year or more, and are often in the way.

The difference between engine and ship drawing may be summed up thus : In engine work there are many straight lines, some circles, and few curves, and in ship work there are many curves, some straight lines, and very few circles. This leads us to remark that in the case of ships' curves it is no easy matter to lay them down, and they have to be judged in great measure by the eye ; it is, therefore, very essential that the ship draughtsman should have sound eyesight, and not suffer in the least degree from astigmatism. Those who suffer from this never see a circle as it truly is, but always more or less flattened.

The checking over of drawings before they go into the shops is not always attended to as it should be, and many costly mistakes have occurred in consequence. Too often the draughtsman depends upon the shop foreman finding out discrepancies before the work goes too far.

The appliances usually provided in these offices are boards, tee-squares, extra large set-squares, long straight-edges, splines or battens, french and ships' curves, weights, sponges, glue-pot, note-books, colour saucers, colours, indian ink, pencils, and sometimes parallel rulers, planimeters, and beam compasses.

## CHAPTER VIII

STRETCHING PAPER, MOUNTING DRAWINGS,  
AND TRACINGS

IF a drawing in pencil only is required on a sheet of cartridge or Whatman's paper it will be sufficient to fasten the paper down with half a dozen drawing pins, or with as many tacks.

If a more finished drawing is required on a sheet of Whatman's unmounted paper, it will be better to stretch it; this can be done either by gluing it down or by tacking it round the margin with tacks placed about 3 or 4 inches apart. If the tacking is preferred, only damp the paper slightly before tacking it down, otherwise when it is dry it will pull away from the tacks. If glue is preferred have the glue and brush ready, then take a lath and lay it along each edge of the paper and fold up about three-eighths of an inch all round. Now take a sponge moderately wet and pass all over the paper on the top side, the edges included; when it has lain a minute or two to expand, put the lath against one turned-up edge of the paper, and pass the glue brush along that edge of the paper which is against the lath, and turn the lath down, thus pressing the glued edge of the paper to the board. Serve the *opposite* edge of the paper in the same way, and, lastly, the other two sides, keep putting the lath upon each edge in

turn, rubbing and pressing them down until they have got firm hold; then leave the paper to dry placed horizontally, for if the board is stood down the moisture in the paper will tend towards the bottom edge and perhaps loosen the glue. Keep examining the paper from time to time and rub the edges down occasionally, but it will not be ready to work on for three or four hours.

If the drawing is to be made on mounted paper—that is, Whatman's paper on brown holland—turn the paper over and sponge the canvas back pretty thoroughly; let it lie a few minutes to expand, and then tack down with tacks about 3 inches pitch beginning in the middle of each edge and gradually working out to all the corners as nearly as may be at the same time; then leave it to dry for about half a day. The tacks may be placed close to the edge of the paper—within, say, a quarter of an inch—and when the drawing is finished of course the edges of the paper can be trimmed up.

In making a tracing on paper, set the drawing square on the board with four tacks or pins, and then fasten the tracing paper down with pins if it is as large as the drawing, if not hold it down by means of lead weights.

In making a cloth tracing, it is well to cut the cloth rather larger than the drawing, and tack to the board just outside the drawing with tacks about 6 inches pitch, and, as the cloth usually expands a little on exposure to the atmosphere, it is a good plan to cut off what is required from the roll and to let it lie open an hour or two before finally tacking it down. Even with this care a sudden change in the temperature will sometimes cause a cloth tracing to become quite baggy whilst it is in progress; therefore, if it is a large tracing containing several views, it is better to work so

as to finish one view right out than to do a little of each all over the board.

The paper on which prints are made is usually too soft to withstand the rough usage of the shops, so the prints are generally mounted on adhesive cloth. This is cloth with a facing of paper, upon which is a layer of gum. To mount a blue or black-and-white print, first damp the print thoroughly, then take a piece of the adhesive cloth an inch or so larger than the print each way, and tack it down on a mounting board, with the gummed side uppermost ; next, with a sponge, wet the gum thoroughly all over, taking care not to wash it off. Now lay the print carefully on the wetted sheet, and roll it down well ; then leave it for the best part of a day to dry thoroughly, after which cut it out by passing a knife round it within the tacks, and trim off square on the cutting board.

To repair old drawings which may be torn right up the middle, take a strip of old drawing paper about 9 inches wide and paste it up the back of the torn drawing ; then take a sheet of linen or brown holland the size of the drawing, tack it on the mounting board, paste it all over, and then lay the drawing upon it, roll it well down, and leave to dry thoroughly before cutting it off. Paper tracings may be mounted on adhesive cloth in the same way as described for prints.

In large offices there is generally kept a handy man to run errands, rub ink, mount or stretch paper and tracings, and do other such services ; but in smaller offices the draughtsmen have to stretch their own paper and mount tracings, so it is quite as well to know how to do so.

## CHAPTER IX

TRACINGS AND BLUE OR BLACK-AND-WHITE  
PRINTS

IN some works it is the practice to send original drawings into the shops to be worked to, whilst in others the original drawings are kept in the office, and only copies of them, in the form of tracings or of photo-prints, are sent out. If tracings are used for the shops, they are generally made on tracing cloth ; this cloth has a shiny side and a rather dull one, and it is a matter of taste on which side the tracing is made, some preferring it on one side and some on the other. If any sections or other work on the tracing have to be coloured, it is better to do the colouring on the reverse side to that on which the lines are, as by so doing there will be no chance of rubbing up the lines, and the colour can be applied very roughly, as long it is kept within the bounds of the lines, and yet look quite neat on the front of the tracing.

If instead of sending the tracing into the shop it is to be used for photo-printing, the sections should be treated as follows. Supposing that "blue prints" are required—that is, white lines on a blue ground—all the sections must be ruled in lines with black ink on the tracing, and the names of the different metals, &c., must be written on or opposite each piece ; but if the

prints are required to be "black-and-white"—that is, a black or dark-grey line on a white ground—the tracing should not be sectioned at all ; but when the prints are taken off they can be coloured with the proper conventional colours to represent the different substances. The "black-and-white" prints are much the best in many respects, and especially when it comes to alterations. In the latter case the lines can be bleached out by the following solution : 3 parts of water and 1 part of strong hydrochloric acid ; apply with a camel-hair brush, and when the lines have disappeared blot the solution up and wash the part with clean water. When the part is quite dry mix a tint to match the other lines, and draw the fresh work in as required ; if the operation has been carefully performed, it will be difficult to find the place afterwards.

It is impossible to alter blue prints (white lines on a blue ground) so that the alteration is not noticeable—the great difficulty being this, that although we can very easily make fresh white lines by using a saturated solution of potassium oxalate, it is impossible to stop out the white lines which we may want to remove so that the alteration cannot be seen. Therefore the only thing to do is to make the alteration as plain and legible as can be. A very good way to do this is to mix together some of the oxalate solution with some ordinary red writing ink, and use with the ordinary pens, &c., direct. The result is that the solution bleaches away the blue ground, and the red fluid colours the line at the same time, and shows up quite distinctly on the blue ground.

Tracings for printing should be done on good tracing paper or cloth, preferably of a bluish tint, and any yellowish tint should be carefully avoided. The ink should be quite black, and the addition of a little burnt

sienna to it is recommended. All centre and dimension lines should be in some opaque red colour, such as scarlet lake or vermillion. If, as is sometimes the case, blue lines are required upon the tracing to show certain work, they will come out very faintly on the prints, and will require to be strengthened up on the latter by hand after the prints are taken.

We may perhaps conclude our remarks on this subject with a brief account of the materials and chemicals used in the two processes we have referred to, they being the two perhaps the most generally in use.

Taking the ferrotype, or white line on a blue ground, process first, the solutions for sensitising the paper are as follows :

|   |                               |            |
|---|-------------------------------|------------|
| A | { Citrate of iron and ammonia | 100 grains |
|   | { Water . . . . .             | 1 oz.      |
| B | { Red prussiate of potash .   | 70 grains  |
|   | { Water . . . . .             | 1 oz.      |

These solutions will keep any time separately, but when mixed they must be used at once or kept in a dark place.

To prepare the paper mix an equal quantity of A and B, and apply freely to the surface of the paper for about two minutes ; then drain off the superfluous liquid, and hang up to dry in a dark room ; the paper will be found then to be of a bright yellow hue.

To take a print, place the tracing in the printing frame with its face to the glass, and then place a sheet of the prepared paper with its sensitised surface next to the tracing, and expose to the light for a period varying from three minutes to half an hour, according to the strength of the light. When the print is taken out of the frame it must be laid in a bath of clean water for ten or fifteen minutes until the lines show perfectly

white. It may then be taken out of the bath and hung up to dry.

In the "Cola" black-and-white process—that is, black lines upon a white ground—the sensitising solution is as follows :

|                     |   |   |   |       |
|---------------------|---|---|---|-------|
| Perchloride of iron | . | . | . | 1 oz. |
| Gelatine            | . | . | . | 2 "   |
| Tartaric acid       | . | . | . | 1 "   |
| Persulphate of zinc | . | . | . | 1 "   |
| Water               | . | . | . | 30 "  |

After taking the print, in the same way as before described, and watching its progress until the blank parts of the paper have turned white, take it from the frame and immerse it in a bath of the following solution :

|                   |   |   |   |       |
|-------------------|---|---|---|-------|
| Gallic acid       | . | . | . | 1 oz. |
| Methylated spirit | . | . | . | 10 "  |
| Water             | . | . | . | 50 "  |

When the lines have turned from the yellow colour with which they leave the frame to black, take the print out of the bath, rinse it in clear water, and hang up to dry.

With regard to preparing the paper, it is perhaps better to buy it ready prepared from a large maker, as by this means more uniform quality will be obtained.

The printing frame is an appliance to which special attention must be given. It must be fitted with a stout and very clear piece of glass, and must be fitted with a back which will bring every part of the prepared paper and the tracing into close contact with the glass, for if there is any space, however small, allowed between the surfaces, it interferes with the print and makes the

lines blurred or very faint. And with regard to the requisite exposure of the prints to the light, it is a good plan to try small pieces of test paper, and note the time required to print to develop to the correct tone and colour, as a guide to properly manipulating the actual prints.

## CHAPTER X

RECORDS AND STORAGE OF DRAWINGS, TRACINGS,  
AND PRINTS

THERE are several systems of booking drawings and tracings, &c., in vogue in different offices, from very elementary ones which are scarcely worth calling systems at all, and which rely almost altogether upon the knowledge or memory of one or two people, to more elaborate ones where every effort is made to record things properly, and thus enable anyone to find the requisite drawing or tracing.

The following method may be found to answer as well as any :

Certain books are kept in the drawing office, viz. "The Drawing Book," "The Tracing and Print Book" (for the works), "The Tracing Book Outwards," "The Tracing Book Inwards," "Letter and Sketch Book," and "Estimate Book."

Besides these, in large works there are special books kept to record the subsequent passage to and fro between the office and the works for alteration or otherwise of all tracings and prints, so that their whereabouts can be discovered at any time.

We will go a little more into detail in reference to the books mentioned, commencing with

## THE DRAWING BOOK

The headings in this are arranged as shown, and one or two sample entries are given :

| Date           | No. of Drawing | Title of Drawing                                                    | No. of Drawer | Draughtsman's Signature | Head Draughtsman's Signature | Date of Completion of Drawing | Remarks                                 |
|----------------|----------------|---------------------------------------------------------------------|---------------|-------------------------|------------------------------|-------------------------------|-----------------------------------------|
| Nov. 15, 1895. | 1068           | General arrangement of stationary engine cylinders, 15 in. x 21 in. | 48            | A.B.                    | X.Y.                         | Oct. 30, 1895                 | At 100 revolutions approximate H.P. 150 |
| Nov. 15, 1895  | 1069           | Detail of cylinders, 15 in. x 21 in.                                | 48            | A.B.                    | X.Y.                         | Nov. 6, 1895                  | —                                       |

## TRACING AND PRINT BOOK (for the works)

In this book are entered all the tracings and prints which are sent into the shops to be worked to, and it is arranged as follows :

| Date          | No. of Tracing or Print | Title of Tracing or Print                              | Tracing or Print | Draughtsman's Signature | Head Draughtsman's Signature | Name of Shop Sent to |
|---------------|-------------------------|--------------------------------------------------------|------------------|-------------------------|------------------------------|----------------------|
| Nov. 17, 1895 | 1,200                   | 15 in. x 21 in. Stationary Engine. Details of Castings | Print            | C.D.                    | X.Y.                         | Pattern Shop         |

## TRACING BOOK—OUTWARDS

This is for the registration of tracings or prints sent

away to other firms or people when tendering or estimating for work, and has headings thus :

| Date | No. of Tracing | Title or Description of Tracing | To whom Sent | Draughtsman's Signature | Head Draughtsman's Signature | Remarks |
|------|----------------|---------------------------------|--------------|-------------------------|------------------------------|---------|
|      |                |                                 |              |                         |                              |         |

### TRACING BOOK—INWARDS

For the registration of tracings, &c., received from outside firms asking for tenders for work, &c. :

| Date Received in Office | No. of Tracing given by Office to Tracing Received | Title or Description of Tracing | From Whom Received | Head Draughtsman's Signature | Remarks |
|-------------------------|----------------------------------------------------|---------------------------------|--------------------|------------------------------|---------|
|                         |                                                    |                                 |                    |                              |         |

### LETTER AND SKETCH BOOK

This is a copying-book, into which all hand sketches and notes affecting work are copied before being sent into the shops, and has an index which is kept posted up so that the sketches, &c., may be readily referred to.

### ESTIMATE BOOK

This is also a copying-book, into which all estimates are copied before being sent away, and is likewise kept carefully indexed.

Drawings are usually stored in drawers made of such a size as to take Antiquarian paper easily—that is, about 56 inches by 34 inches—and of such a depth, about 2 inches, as to hold, say, fifty drawings.

Each drawer is kept for a certain class of work, and is labelled accordingly as "stationary engines," "tools," "hydraulic hoists," or "cranes," and is also provided with a number. Every drawing is numbered with the drawer number and a number of its own written in the form of a fraction, thus :  $\frac{48}{1088}$ , the top figure being the drawer number and the bottom one that of the drawing. Each drawing as it is entered in the book takes the next number to the preceding one, and, as far as possible, drawings of the same piece of machinery, tool, or building are kept together ; thus, supposing the draughtsman is about to get out a set of drawings for a stationary engine, and he requires to make six drawings, such as "general arrangement," "cast details," "wrought details," &c., he would secure six consecutive numbers in the book, and when the drawings were made they would be entered in the book and numbered accordingly. The drawings should also always be kept in consecutive order in the drawers, as this enables them to be picked out with greater facility.

Each tracing is also numbered in its turn as it is entered in the tracing book, and it is also signed by the head draughtsman to certify its correctness, and by the manager of the works as authority to the foreman to proceed with the work. The tracing is also stamped with the name of the firm and the date, for which purpose a rubber stamp, in which the date can be changed daily, is used ; the stamps vary in shape, but the round or the oval form are very frequently used.

When a tracing is made from a drawing a note to that effect is put on the latter, and the number of the tracing is also given, with the date. Where there is a set of drawings belonging to one job it is very useful to put on the general arrangement drawing a list of all the detail drawings, with their numbers, and also on

the general arrangement tracing a list of all the detail tracings, with their numbers, so that the foremen and workmen can see at a glance what tracings are sent out for them to work to.

While we are mentioning these little arrangements for saving trouble, we may point out one more that does not always receive sufficient attention. In many cases certain parts of engines or pieces of machinery are brought in over and over again for different work. These parts are often just shown on the new drawing, without any dimensions or other particulars, but with simply a note to say similar to so and so on tracing No. —. This practice causes great waste of time in the shops, and it is much better to let the draughtsman show the piece and fully dimension it over again, and at the same time add a note to the effect that it is similar to something that has gone out before, to remind the foreman and others that there is a pattern or template for it.

All patterns as they are made are stamped with a number, or have one painted upon them, and when these are brought in for another piece of work their numbers should be given upon the drawing and tracing.

## CHAPTER XI

## THE PLANIMETER AND ITS USE

FIG. 73 shows an ordinary form of the planimeter, and fig. 74 an enlarged view of the recording portion of the apparatus. The dial A is divided into ten parts

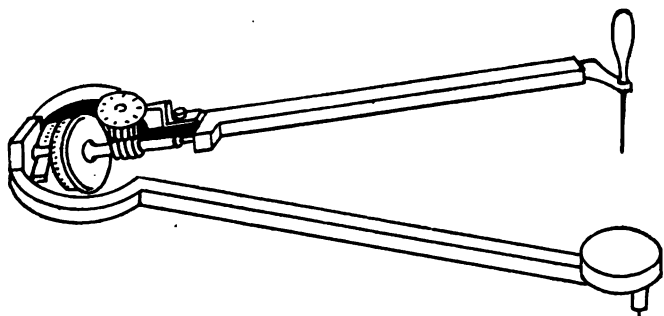


FIG. 73

and the wheel B is also divided into ten parts, but the wheel B rotates once whilst the dial makes  $\frac{1}{10}$ th of a revolution. Therefore, if we call the figures on the dial units, those on the wheel will be  $\frac{1}{10}$ ths. Each tenth of the wheel is subdivided into 10 again, therefore the subdivisions count for  $\frac{1}{100}$ ths; and as the vernier C, which equals  $\frac{9}{100}$  of the wheel divided into ten parts

again, will give us  $\frac{1}{1000}$ ths, it will be seen that we can read the instrument off to three places of decimals. Thus, supposing it is in the position shown in fig. 64, we get units 2 from the disc, '45 from the roller, and 9 from the vernier, the figure from the vernier being taken from that division which is exactly opposite one on the roller, the complete reading being 2.459.

The best way to obtain freedom and proficiency in the use of the instrument is to mark out on a sheet of paper (which must be level) some plain figure, of

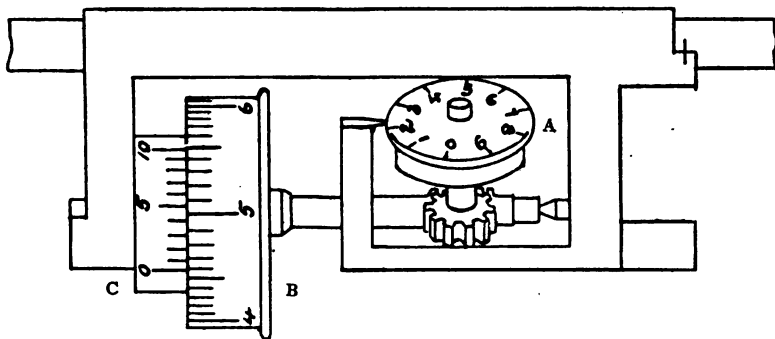


FIG. 74

which the exact area is known, say a square of 3 inches side ; of course, we know that the area of this will be exactly 9 square inches. Now set the instrument, as shown in fig. 75, with needle point E at any convenient place outside the area to be measured, then place the pointer D at one corner of the square. Note the reading of the dial and wheel whatever it is, without troubling to place the figures at zero, and, say the record was 2.718, then carefully follow the outline of the square once round, leaving off exactly where we started, and

take the reading again; it will be 3·618. Now deduct 2·718 from 3·618 and we have ·9, and this figure  $\times 10 = 9$  square inches, the exact area of the figure. And in every case the difference between the two readings, multiplied by 10, will give the area in square inches. It is usual to work the pointer round in the direction of the apparent travelling of the sun or of the hands of a watch, but it makes no real difference which way the pointer is travelled, for the differences between the readings will be exactly the same. To prove this suppose the last reading taken, 3·618, is an initial reading, and reverse the travel of the pointer round the

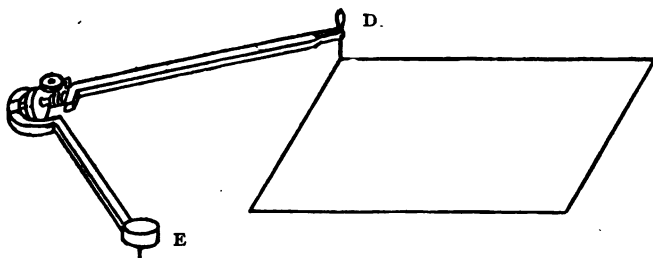


FIG. 75

figure, then the second reading will be 2·718, and, of course, the difference between the two will still be ·9.

The area of any small figures are taken with the needle point outside of them, but with larger figures it becomes necessary to put the needle point within the figure to be measured, as shown in fig. 76. Following our former practice, let us take a circle 10 inches diameter, the area of which is known to be 78·54 square inches. Place the needle point E somewhere near the centre of the figure, and press point D lightly into the paper anywhere in the circumference of the circle, and take a reading off the dial, &c.; then go roughly round

the figure in the direction of the sun, and at the same time watch the dial and note if the figures upon it make a forward movement or a backward one, and note also if the zero mark is passed once or twice. If the figures on the dial make a *backward* movement, proceed as follows: Begin again at the mark in circumference of circle and read off dial, &c., carefully; suppose the reading is 6'090, then follow the circle round to the same place again, and the second reading will be 2'652. As the dial moved past the zero once, we must add ten

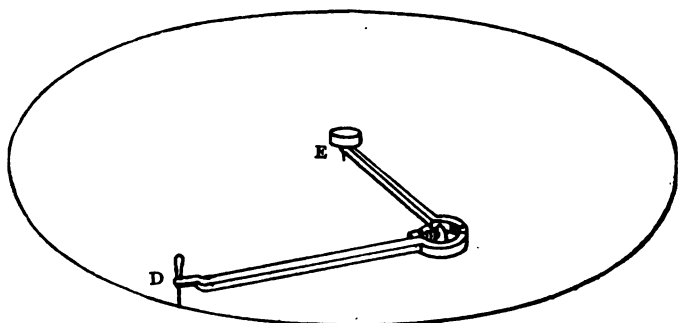


FIG. 76

to the first reading, thus making it 16'090; now, deducting the second reading from the first, we get 13'438, and this figure has to be deducted from the number printed on the weight on an ordinary planimeter, or on the bar over the unit mark on an adjusting planimeter; the number in our case is 21'292, and this minus 13'438 equals 7'854, which, multiplied by 10, gives us the right answer, viz. 78'54. We will now put these figures in a tabular form that they may be seen more readily.

First reading (+ 10  
as counter went once  
past zero) . . . } = 16.090

Second reading = 2.652

Difference = 13.438

Fig. printed on bar = 21.292

Difference as above = 13.438

7.854

10 = constant multiplier

No. of square inches = 78.54

It depends upon where the first reading happens to come as to whether the dial passes the zero mark one or more times, and we will now give an instance where the zero would be passed twice, taking the same sized circular figure as above.

First reading 1.487  
(+ 20 as counter went  
twice past zero) . . . } = 21.487

Second reading = 8.049

Difference = 13.438

Then, as before, fig.  
printed on bar . . . } = 21.292

Difference as above = 13.438

7.854 × 10 = 78.54 sq. in.

Now, we will take an example where the dial will make a *forward* movement when recording, and, as this will require a larger figure, we will assume that we want to obtain the area of a circle 20 inches in diameter, the area being 314.16 square inches.

Instead of deducting the second reading from the first, and then *deducting* the difference from the number on the bar, as we did in the case of the *backward* move-

ment, we now deduct the first reading from the second, and *add* the difference to the number on the bar, thus :

$$\left. \begin{array}{l} \text{Second reading } 1'800 \\ (+ 10 \text{ as counter went} \\ \text{once past zero}) \end{array} \right\} = 11'800$$

$$\text{First reading} = 1'676$$

$$\text{Difference} = 10'124$$

$$\text{No. on bar} = 21'292$$

$$31'416$$

$$\underline{\hspace{1cm}} 10 = \text{constant multiplier}$$

$$\text{No. of square inches} = 314'16$$

If the counter had gone twice past zero, we should, of course, have added 20 to the second reading.

To find the area of figures which are drawn to scale, proceed as follows: Obtain the actual area of the figure in square inches, as shown, and then multiply the result by the square of the scale; thus, in the case of  $1\frac{1}{2}$  inches to the foot, as there are eight  $1\frac{1}{2}$  inches in a foot, or the scale is  $\frac{1}{8}$ th the full size, we should multiply by  $8^2$  or 64. In the case of  $\frac{1}{2}$  inch to the foot we should therefore multiply by  $24^2$  or 576, and thus in each case obtain the actual number of square inches in the required area. This can easily be verified, as before, by taking a square 3 inches each way, and then supposing it to represent a drawing at  $1\frac{1}{2}$  inches to the foot, and afterwards one at  $\frac{1}{2}$  inch to the foot, and comparing its known areas with those found by the planimeter.

One very useful purpose to which the instrument can be applied is to find the areas of indicator-diagrams and their mean pressures, without resorting to ordinates or in any way defacing the diagrams. To perform this operation with an ordinary planimeter proceed as

follows : Take the difference of the two readings before and after running the pointer round the diagram, then multiply this difference by the scale of the diagram, and divide by its actual length in inches ; the answer will be the mean pressure in pounds per square inch.

The following instance is taken from an actual diagram :

$$\begin{array}{rcl}
 \text{Second reading} & = & 0.414 \\
 \text{First} \quad \quad \quad & \text{,,} & = 0.180 \\
 \text{Difference} & = & 0.234 \\
 & \times & 10 = \text{constant multiplier} \\
 \hline
 & & 2.34 \\
 & \times & 40 = \text{scale of 40 lbs. to 1 inch.} \\
 \hline
 \text{Length of diagram} = 4'' & \times & 23.4 \\
 & & \hline
 & & 93.60 \\
 & & = \text{mean pressure in lbs.} \\
 & & \text{per square inch.}
 \end{array}$$

Special planimeters are made for indicator-diagram work of the form shown in fig. 77. In using these set the two points on the top of the bar to the length of the diagram, then take the difference of two readings

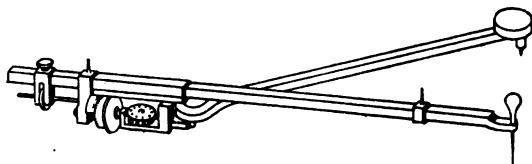


FIG. 77

as before, multiply this difference by the scale, and divide by 0.4 ; the answer will be the mean pressure in lbs. per square inch. Thus, to give an instance in

figures, from the same diagram as in the preceding example—

Second reading = 0.941

First        „        = 0.707

Difference = 0.234

40 = scale of 40 lbs. to 1 inch.

Constant divisor = 0.4 ) 9.360

23.4 = mean pressure in lbs. per square inch.

In the case of working out indicator-diagrams with the planimeter, we would recommend the beginner to take a diagram and find out the mean effective pressure in the usual manner by ordinates, and then try to obtain the same result with the planimeter. With this method of working on figures of known area the operator will gain confidence, and so feel quite satisfied with the results that he may obtain afterwards from the instrument when dealing with figures of a complicated form.

## CHAPTER XII

## CONCLUSION

WE propose to finish our hints to beginners with a few notes on points not previously touched upon.

*Transferring drawings.* It is often necessary to transfer a drawing or a portion of one from one sheet to another, sometimes to the same scale and at others to a larger or smaller scale. Supposing it is to be on the same scale, proceed as follows: Trace off the work carefully with a fine pencil on a piece of thin tracing paper, then if the object is only small rub over the back of the tracing with a soft blacklead, such as a B B ; next place the tracing in proper position on the fresh sheet, and pin or weight it down, and again go over the lines with a stylus, or a smooth but hard-pointed pencil, when the object will be found printed on the paper. The lines can then be strengthened with pencil or inked in as required. Another method of transferring drawings to the same scale is to place the one drawing upon the other, and prick all points and corners through, after which the top drawing is removed, and lines are drawn from the various points; this is, however, a very tedious process, and one liable to lead to errors.

To transfer a drawing to a different scale a very good method is the following: Divide the drawing up into small squares, and the fresh sheet into the same number of squares, but larger or smaller as required by the

scale ; then draw in the work in the corresponding squares.

An instrument called the pantagraph is sometimes used to reproduce drawings to the same or other scales ; it is advisable, however, not to use it to enlarge a drawing, but only to reduce one, the reason for this being that in the one case any errors are magnified, but in the other they are minimised. As it is an instrument not commonly used, we need give no further particulars of it.

The draughtsman should be methodical in all things ; he should do all his calculations in a book, and date and preserve them, so that he can always refer to them when required. He should also always put a date to every sketch or scheme that he makes, for very important issues sometimes hang upon the date when a certain design was got out. And for his own guidance he should note down any special formulæ, &c., that he comes across, but which are not, perhaps, in his ordinary books of reference. In course of time a man accumulates a quantity of books, papers, and notes, and cannot always remember where he can find what he requires. A good plan to get over this difficulty is to keep a rough index of all things which strike him as likely to be useful, and where they are to be found ; if this index is kept posted up it will be found of great use.

There are two simple geometrical problems which are very useful to the draughtsman, and which are frequently overlooked, perhaps from their very simplicity. They are to make a scale of chords, and to divide a line into any number of equal parts.

To make a scale of chords, describe a semicircle with any convenient radius, say two inches, and divide the semicircle into eighteen parts. Each part will then represent  $10^{\circ}$  ; these parts can then be subdivided into

ten again, and each of these will represent  $1^\circ$ . Then from one end of the semicircle, describe arcs from each

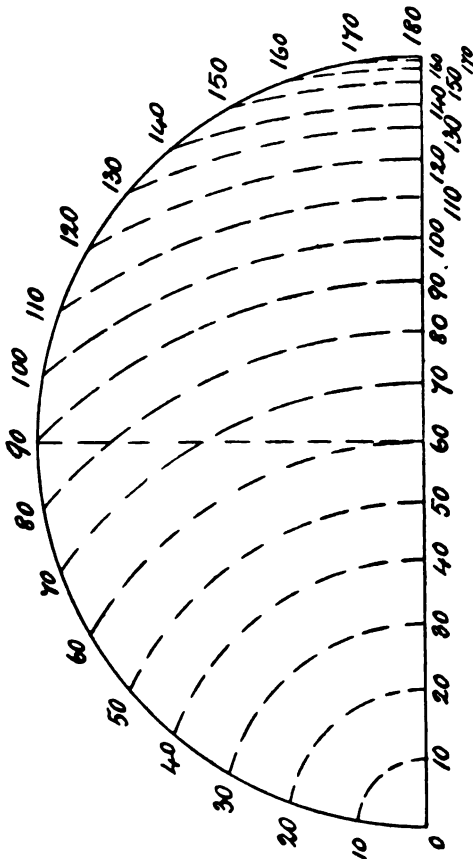


FIG. 78

tenth degree to cut the base line, and number them as shown in fig. 78.

Now, suppose we wish to lay off an angle of  $50^\circ$  from line  $AB$  at point  $B$  in fig. 79. With point  $B$  as centre, and a radius of 2 inches, describe a portion of a circle; then measure off chord of  $50^\circ$  by the compasses from  $O$ , and set it off from  $A$  in point  $C$ ; join  $BC$ , which will make an angle of  $50^\circ$  with  $AB$ . So for any angle, but always using a 2-inch radius, or whatever other radius has been used in constructing the scale of chords. If this is neatly worked out it can be pasted in the cover of a book, where it can always be got at, and will serve instead of a protractor.

To divide a line into any number of equal parts. Suppose we wish to divide line  $AB$  (fig. 80) into ten

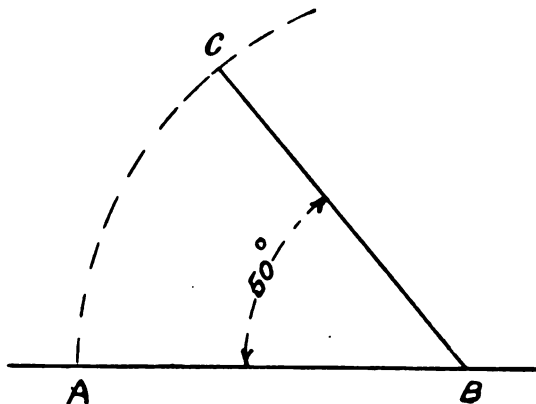


FIG 79

equal parts; from either end, say  $A$ , draw a line at any angle with  $AB$ , and with any convenient scale mark off ten parts along this line. Join the tenth part to  $B$ , and draw lines parallel to that from the other divisions to cut  $AB$ . The latter will then be divided into ten equal parts. Of course, the lines need not be actually drawn

as long as the ticks on AB are made parallel to line joining IOB.

Without attempting to give a complete list of books which might be useful to beginners and others, we will append a list of some which may be profitably studied. Many of them are recognised text-books in use at technical classes. The published prices are quoted, and,

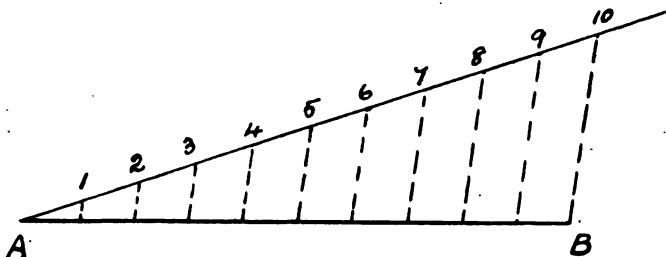


FIG. 80

generally speaking, a discount of 25 per cent. can be obtained by ordering the books through proper channels.

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"Algebra, Advanced," by Todhunter, 7s. 6d.

"Euclid," by Todhunter, 3s. 6d.

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"Graphic Statics," by Clarke, 12s. 6d.

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"Handy Book of Strains," by Humber, 7s. 6d. A valuable book, but more advanced.

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"Elements of Mechanism," by Goodeve, 6s.

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"Cranes and Lifting Machinery," by Marks, 2s. 6d.

"Steam Engine," by K. Clark, 48s.

"Handbook on the Steam Engine," by Haedar & Powles, 9s.

"Steam Boilers," by Wilson, 6s.

"Survey of the Hull, Equipments, and Machinery of Steamships Carrying Passengers," 6d. Very useful to those engaged in boiler work.

"Text-book on the Steam Engine," by Goodeve, 6s.

---

\* These are annuals, and contain useful information about gas-engines, indicating, &c.

"Locomotive Engineering," by Colbourne. This work can be consulted in many libraries.

"Steam Engine Indicator," by Beaumont, 3s. 6d.

"Pumps : Historical, Theoretical, and Practical," by Björling, 7s. 6d.

"Surveying," by Merritt, 12s. 6d. This book is fully illustrated, and contains the necessary arithmetic, trigonometry, and geometry required.

"Principles of Pattern Making," published by Whittaker & Co., 3s. 6d.

"Magnetism and Electricity, Elementary," by Jamieson, 3s. 6d.

"Elementary Electricity," by Sylvanus Thompson, 4s. 6d.

"Electrical Engineering," by Slingo & Brooker, 10s.

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"Building Construction," Rivington's. Vol. I., 10s. 6d. ; Vol. II., 10s. 6d. ; Vol. III., 21s. ; Vol. IV., 15s. These are good books. Vols. I. and II. give all kinds of details, well illustrated ; Vol. III. deals with materials, and Vol. IV. with beams, girders, roofs, arches, &c.

"Mechanical Drawing Copies," by Busbridge, comprising all kinds of details, 3d. per sheet. Architectural ditto, same price. These copies are very useful to students.

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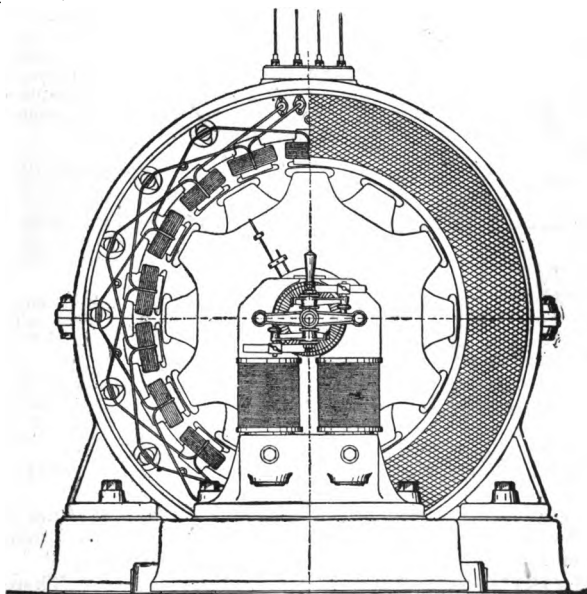
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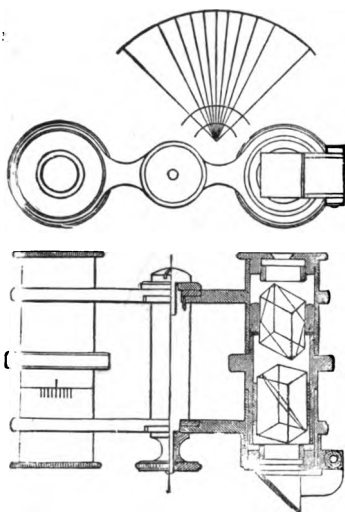


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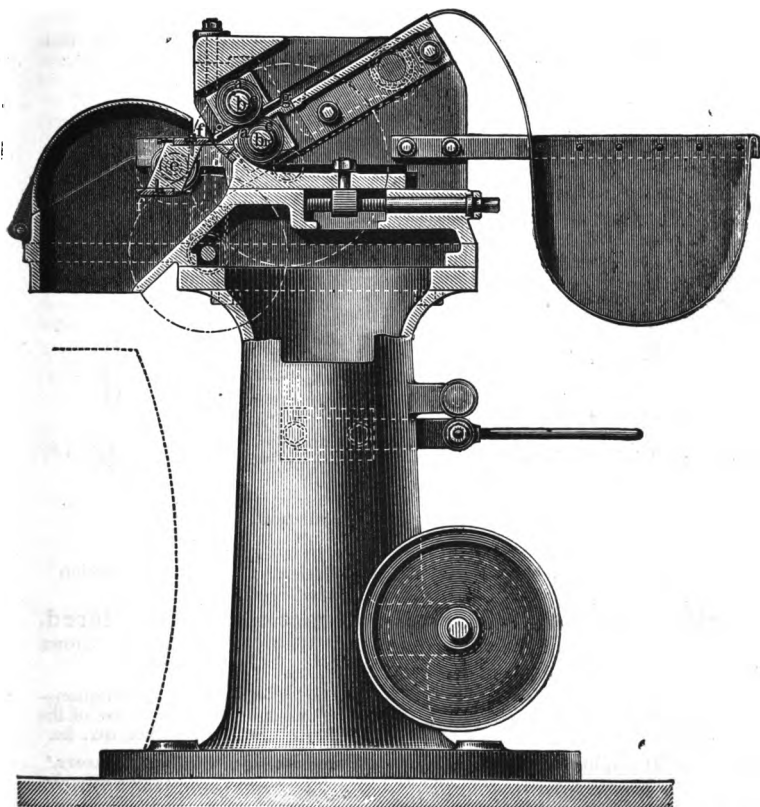
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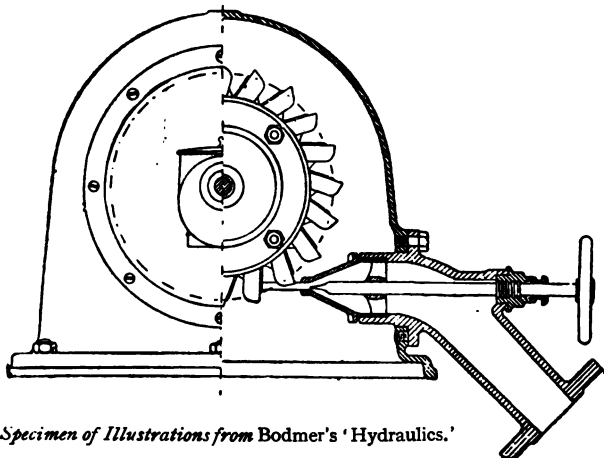
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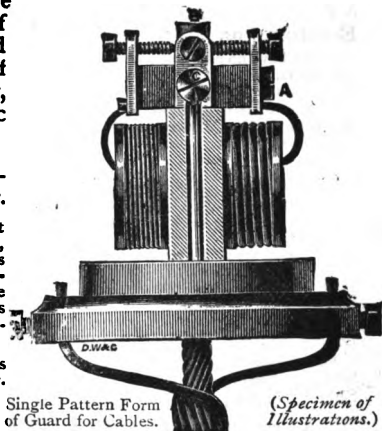
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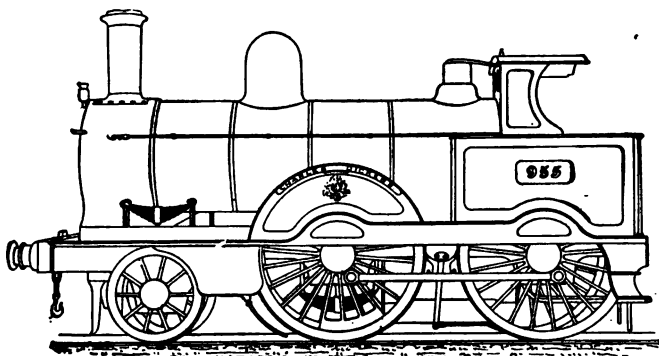
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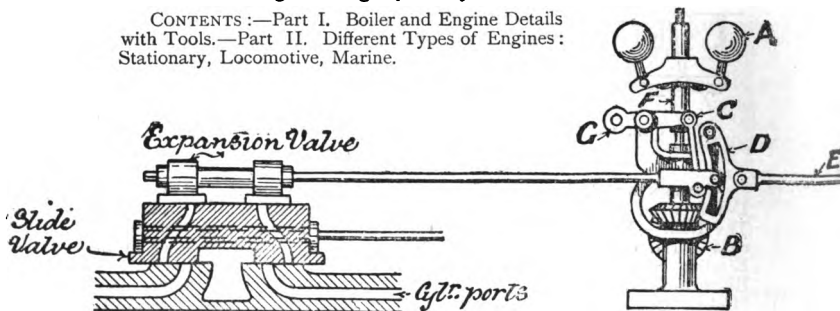
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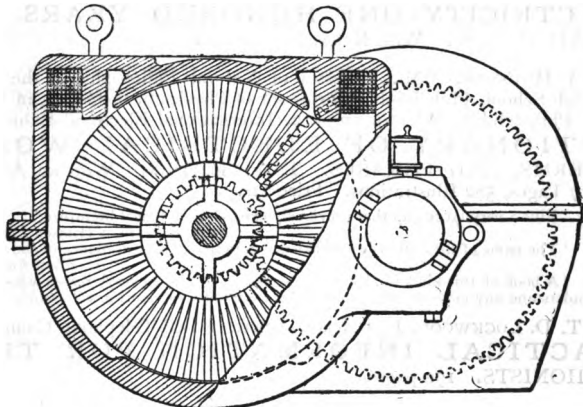
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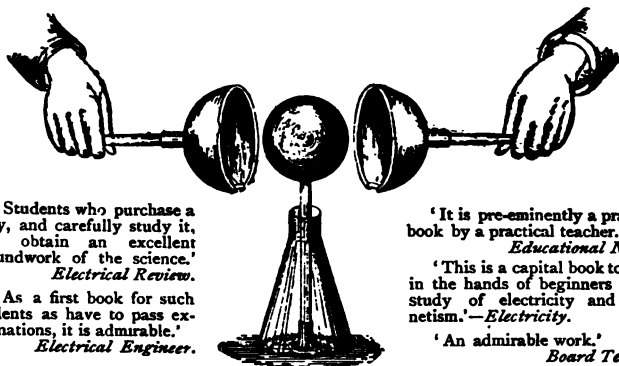
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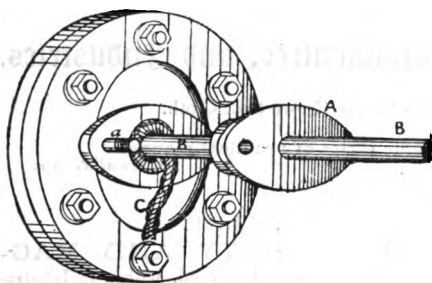
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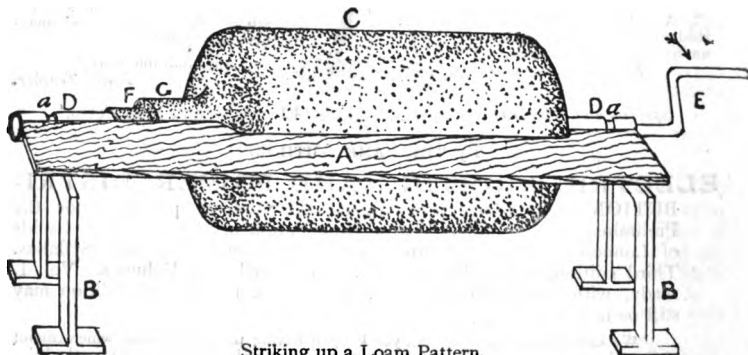
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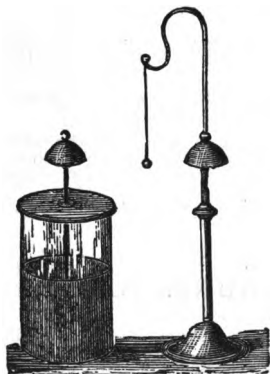
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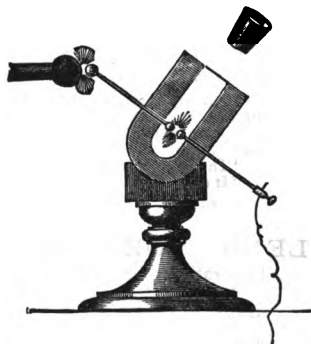
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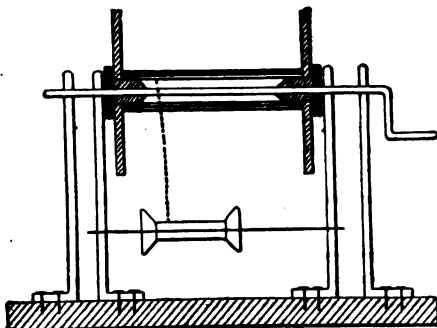
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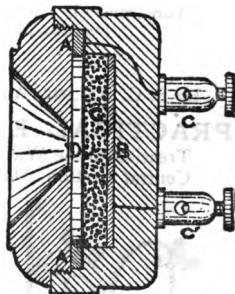
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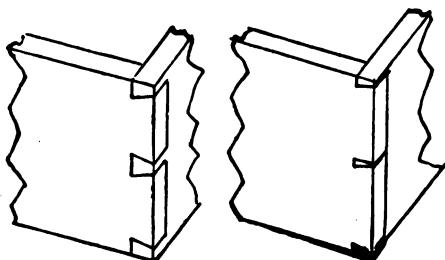
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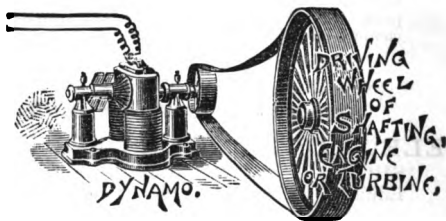
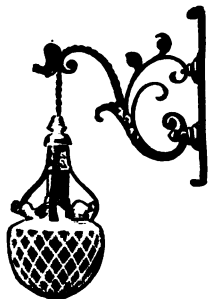
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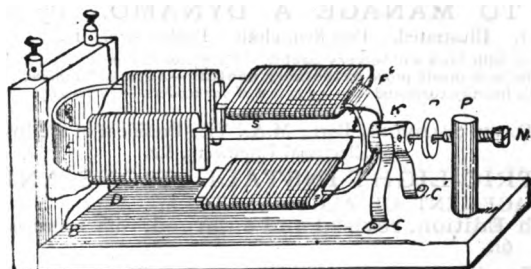
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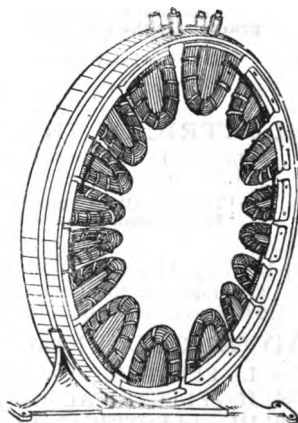
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